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Sewer Clogging Prediction System Based On Machine Learning Using Iot

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ABSTRACT: India has a huge population with many densely crowdedcities andtowns.So adoptionof a smart undergrounddrainage system is very essential. In order to maintain a city that is clean, safe and healthy at all times, the functioningand monitoring of the entire sewersystem plays a key role. This paper focuses on designing an embedded system with IoT to track down such effluents andgenerate alert signals through wireless networks. In this proposed system, the hardware consists of water flow sensor,water level sensor, rain sensor and gas (methane) sensors, that are collectively used on-site in remote locations tomeasure the water flow rate, water level and gas level in a working sewer. The sensor values are fed to Raspberry Pi3Microcontroller which is the 64-bit quad-core ARM Cortex-A53 processor, with 512 KB shared L2 cache. This paperaims at developing an affordable autonomous sewerage system using IoT and overflow prediction is done by usingmachinelearningandwithouthumaninterventio n.Forproperoperationofsewagesystem,realtimedata collection is done andprediction ofthe level of sludge and significant of the sewer block is carried out water is carried out. Higher runoff volume with large impervious ground and exponentialpopulation growth when exposed to intense rains have overwhelmed the drainage system causing inundation and blockage. These allcould be avoided if a smart system that detects both the water level and water flow rate. A smart system based on IoTwith appropriate analysis of sensor data could be used that would provide real time information monitoringand reporting the data to Municipality or concerned authority. This will prevent manual drain inspection and enablesimmediate response without human intervention or delay. Owing to the difficulty in modelling the complexities ofsewerconditiondeterioration, applicationofArtificial Intelligence (AI)-based techniques such as Decision Tree algorithms has been implemented to develop models that can infer an unknown structural condition based on the data fromsewers that have been inspected and predictive analytics carried out. As a whole, this paper represents the implementation anddesignfunctionsformonitoring,detectingandman agingunderground drainagesystemwith differentapproaches as a part of smart city implementation.

Keyword: Internetofthings(IoT), Monitoring,MachineLearning (ML),Detecting, Predictionforsmartcity.

I. INTRODUCTION

Drainage system plays a very important role inbig cities where millions of people live.Ingeneral, any drainagesystem is known as the basis for land dryness because excess of unused water which include both rain water andwaste water. Drainage conditions should be monitored in order to maintain its proper function. In fact, not all areashave drainage monitoring team. This leads to irregular monitoring of the drainage condition. Irregular monitoring hasmainly contributed to the blocking of the drainage that triggers drainage water flooding in the neighborhood mainly inresidential areas. Manual monitoring is also highly incompetent. It needs a lot of dedicated persons who are only ableto record limited report with low accuracy. The problem arises in such drainage lines that can cause serious issues tothe daily routine of the city. Problems such as blockage due to waste material, sudden increase in the water level aswell as various harmful gases can be produced if proper cleaning actions are not taken

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time to time. Today's drainagesystem is not computerized due to which it is hard to know if any blockage has occurred in a particular location. Also,sometimes due the accumulation of waste in these drainage lines various toxic gases like methane (CH_4) etc. whichare harmful and can cause serious problems if inhaled by humans in large amount. These problems are generallyfaced by the drainage workers who have to enter into these sewer lines that can lead to death. Also, there are no prioror early alerts of the blockage or rise in amount of those gases accumulated underground or even the increase in waterlevel. Hence detection and repairing of the blockage becomes time consuming and hectic. Wireless Sensor Network(WSN) is a monitoring technology which is a network of node sensors that expanse and integrate with the use of awireless network system. Every node consists of a data processor (Raspberry Pi 3 controller), memory (program, data,flash memory), Power supply system along with four sensors. Using IoT, the collected data is disseminated to variouscontrol sections to operate the driver relays that flush out the waste water collected from the blockage areas to far offlocations. Machine learning is a branch of artificial intelligence (AI) and computerscience whichfocuses onthe useof data and algorithms to imitate the way that humans learn, gradually improving its accuracy. Machine learning (ML)is the study of computer algorithms that can improve automatically throughexperience and by the use of data. It isseenasapartofartificialintelligence.Machinelearningalgorithmsbuildamodelbasedonsampledata,known as trainingdata,inordertomakepredictions ordecisions withoutbeingexplicitly program.Machine learningalgorithms areusedinawidevarietyofapplications,suchasinmedicine, emailfiltering, speechrecognition,and computervision, where it is difficultorunfeasible to developconventional algorithms to perform the neededtasks. A subset of machine learning is closely related to computational statistics, which focuses on making predictionsusing computers; but not all machine learning is statistical learning. The study of mathematical optimization deliversmethods, theory and application domains to the field of machine learning. Data mining is a related field of study,focusingon exploratorydataanalysis through learning.Someimplementationsofmachinelearningusedataand neural networks ina way that mimics the workingof abiologicalbrain.Inits applicationacross businessproblems,machinelearningisalsoreferredtoas predictiveanalytics.

II. PROPOSED SYSTEM

The underground drainage system is an important component of an urban infrastructure. It is considered to be a city'slifeline. Most management on underground drainage is manual. Therefore, it is not efficient to have clean and workingunderground system. Also, in such big cities, it is difficult for the government personnel to locate the exact manholewhich is facing the problem. Today's drainage system is not high-tech. So, whenever there is blockage, it is difficultto figure out the exact locationof the blockage. Also, early alerts of the blockage are not received. Hence detectionandrepairing of the blockage become time consuming. It becomes very inconvenient to handle the situation whenpipes are blocked completely. Due to such failure of drainage line people face a lot of problems. Internet of things(IoT)possess an immense scope in field of sewerage management system for both collection and analysis of the datarelated to environment and physical parameters and their effects.Theseadvancementscould be implemented throughthe use of Wireless Sensor Network which would generate critical data of various factors (environmental and others)that could be properly visualized using Geographic Information System (GIS) and appropriate data science model toproactivelyperformrequiredchangeswithouthumaninvolvement.

III. METHODOLOGY

SewercloggingpredictionbyusingMachineLearning(ML)system

This paper focuses on designing an embedded system with IoT to track down effluents and generate alert signalsthrough wireless networks. In this proposed system, the hardware consists of water flow sensor, water level sensor,rainsensorandgas(methane)sensorthatarecollectivelyusedon-siteinremotelocationstomeasurethewaterflow rate,waterlevelandgaslevelinaworkingsewerasinFigure1.ThesensorvaluesarefedtotheRaspberrypi3 microcontroller. This paper aims at developing an affordable autonomous sewerage system using IoT for notification while overflow prediction is done by using Machine Learning and without human intervention. For proper operation of sewage system, real time datapredicting the level of sludge and water is very important. Higher runoff volume, with large impervious ground,exponentialpopulationgrowth when exposed to intense rainshave overwhelmedthedrainage systemcausing inundationandblockage. This all could be avoided

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if a smart system that detects both the water level as well as water flow rate. A smartsystem based on IoT principles with appropriate analysis of sensor data could be used that would provide real timeinformation monitoring and reporting the data to Municipality or concerned authority.

IV. BLOCK DIAGRAM

Based on drainage monitoring guidelines, the following parameters are monitored. They are

1. Blockage in the pipes
2. Detection of hazardous gases
3. Detection of water level and water flow rate.

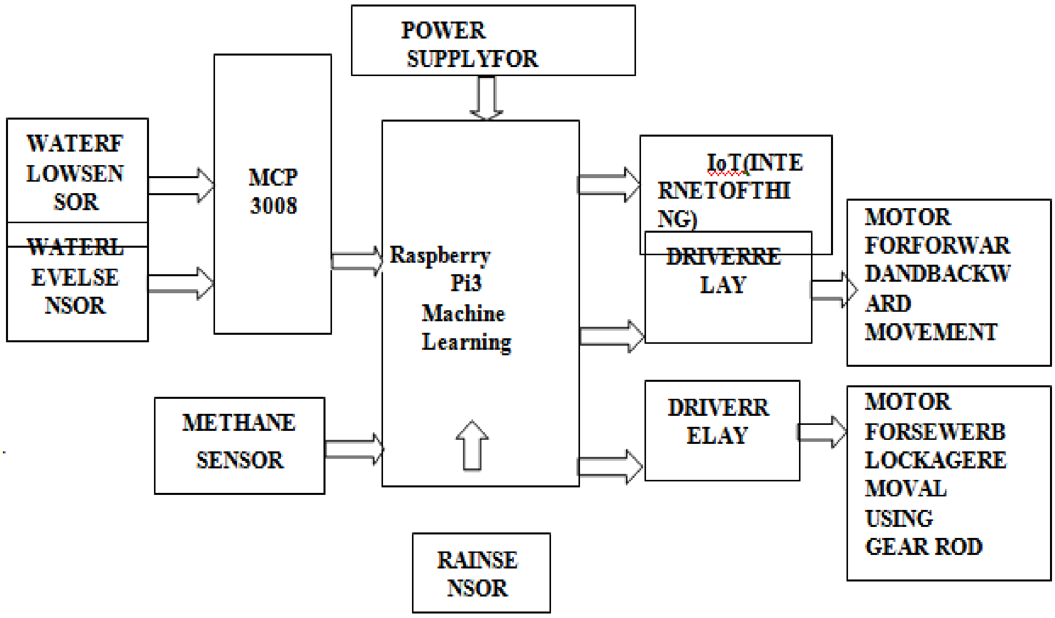

Figure 1. Block diagram of Sewer System

The sensor used are water level sensor, water flow sensor, rain sensor and gas detection sensor. Water flow sensor used for flow measurement it consists of a plastic valve body, a water rotor, and a hall-effect sensor. When water flows through the rotor, rotor rolls. Its speed changes with different rate of flow. The hall-effect sensor outputs the corresponding pulse signal. The water level increases while the rainfall is excessive and when there is an excess discharge of waste water. The gas sensor is used to measure the presence of particular gases as well as the quantity and concentration of those gases. The methane gas sensor is used to sense the gases such as methane (CH_4). The blockage removal mechanisms are enabled with driver and relay circuit as well as controlled through the IoT module. The output values of water level sensors, gas sensor and blockage detection are conditioned as standard input signals to the microcontroller. The output of signal conditioning will be input to the internal ADC (Analog to Digital Converter) of Microcontroller. The gateway is a sensor node that has additional functions to send data to the server. The communication mode that is used in this design is Wifi connection. This component is used to send the entire collected data through Machine Learning algorithm and Decision Tree is used to predict the drainage overflow condition. All the components are attached to the manhole cover with the calibration such that each part is able to perform its task correctly. The data from various sensors would be collected to locate the clogged spot. Intelligence of sensors and predictive systems identify the clogged spots and give details for Machine Learning algorithm for further actions to be taken. To clear the blockage and also complete blockage removal using the setup which is a movable motor with the help of rotating motor blade and gear rod has been configured.

This proposed system consists of water flow sensor, water level sensor, rain sensor and gas (methane) sensor which has been designed for use in-the-field in a remote location to measure water flow rate, water level, gas level in a working sewer. Also the prediction of the exact status of scavenging is carried out using Machine Learning algorithm. The sensor values are fed to Raspberry

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Pi. This paper aims at developing an affordable autonomous sewerage system using IoT that works without human intervention.

V. HARDWARE IMPLEMENTATION

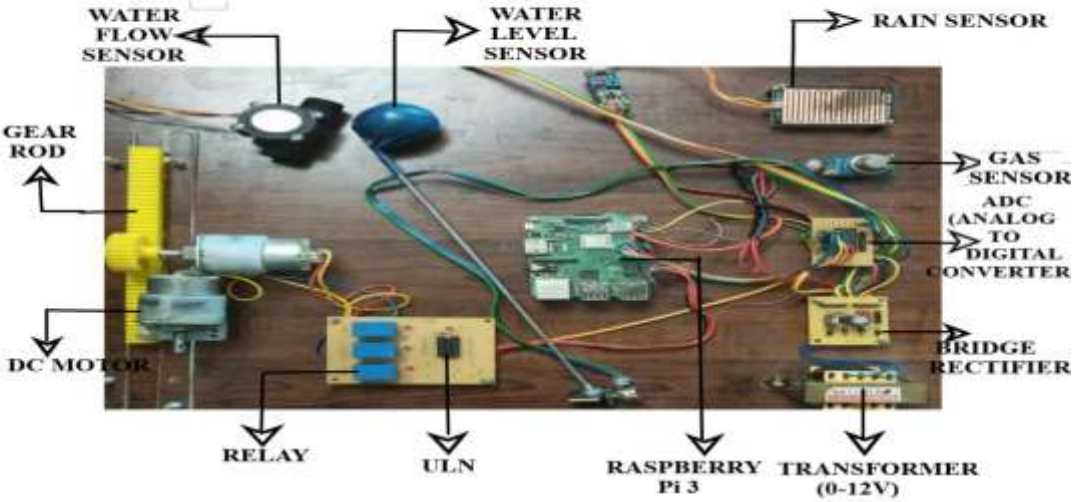

Figure 2. Hardware of Sewer System

The hardware sewer system is shown in Fig.2. When the power supply is switched 'ON' , all the sensors will get activated and controlled by python programming. They will start sensing. The python program runs and the measured data from the sensors are fed as input to the start detecting controller. The sensors that are used mainly for blockage detection are the Water level sensor,water flow sensor, rain sensor and the methane gas sensor.

Water level sensor is used to determine the change in water level of the drainage system. The water level increases in the drainage while rain fall is excessive and when there is an excess discharge of waste water. The water level sensor output value can increase from 0 upto 1000.

Water flow sensor is used to determine the flow of water through the rotor. The rotor rolls and its speed changes with different rate of flow.This sensor detects the flow in the drainage. If the sensor detects a change in rate of flow then the output varies. Water flow rate varies from 0 to 1023.

Rain sensor is used to detect the rainfall water droplets. Rain sensor is basically a board on which nickel is coated in the form of lines. It works on the principle of resistance and the rain sensor module allows to measure moisture. The rain senor module is an easy tool for rain fall detection and it can be uesd as a switch'ON' device. When rain drops fall on the rain sensor board it responds by also measuring the rainfall intensity. As the rain drop falls, rain board power indicator LED is switched 'ON' and it will show the output value as 1.

Methane gas sensor is used to sense the toxic gases such as methane gas [CH_4]. This sensor detects the gas formed in the underground system and it will show the output value as 1. All the sensor signals are conditioned as standard input signal for Raspberry Pi. Output signal conditioned input is given to ADC (Analog to Digital Convertor).The sensor node sends the data to the server. The communication is esablished using Wifi connection, monitored and predicted by python programming language and Machine Learning by using IoT.

This intelligent sensor node checks water flow rate continuously and sends automatic email by using IoT module. Sewer clogging prediction is done using the Machine Learning based on Decision Tree algorithms. This Decision Tree is a flowchart-like tree structure. It learns to partition on the basis of the attribute value. Decision Tree can handle high dimensional data with good accuracy. This intelligence of sensors and predictive system identify the clogged spots and gives the instructions for further actions to be taken by the implementation of Machine Learning algorithms. Then testing the clogged spots, the blockage removal mechanism enabled with driver and relay circuit help to clear the blockage and also remove the blockage by using the motor with the help of movable blade as well as gear rod. Owing to the difficulty in modellingthe complexities of sewer condition deterioration, application of Artificial Intelligence (AI)-based techniques such DecisionTreealgorithmstodevelopmodelsthatcaninferanunknownstructuralconditionbasedondatafromsewersthathavebeeninspected,isimplemented.

VI. RESULT AND DISCUSS

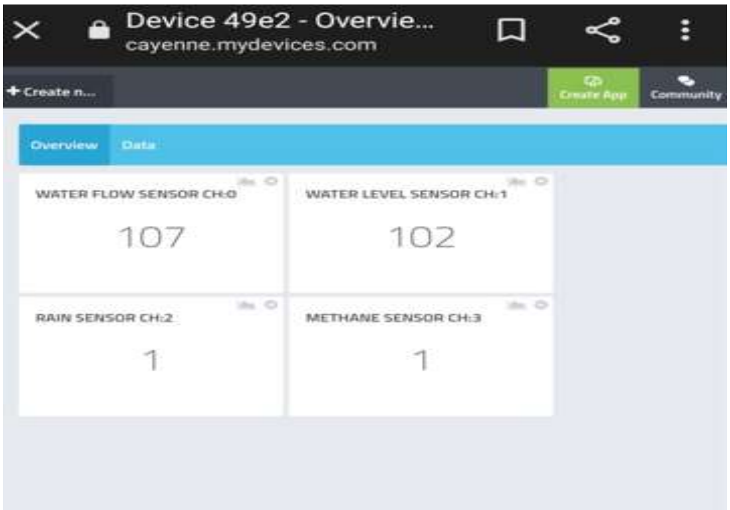

Figure3. Measurement of Sewer Clogging

The sewer clogging prediction system monitors using Cayenne software. It shows the measurement of sensors using IoT and the data collected is sent as email notification. This system detects the drainage water level and blockages in the sewer system. The system also checks the water flow rate continuously and sends email notification by using IoT module.Underground sewer monitoring is a very challenging problem. This paper discusses different methods for monitoring and managing underground drainage system. The various applications like underground drainage and manhole identification can be done in real time. Various parameters like temperature, toxic gases, water flow and level of water are monitored and updated through the internet using the Internet of Things. This enables the person in-charge to take the necessary actions regarding the same. In this way, unnecessary trips to each manhole in the entire city are saved. The number of trips can be minimized and only be done whenever required. Also, real time update on the internet helps in maintaining the regularity in drainage check thus avoiding the hazards. Figure 3 shows the screenshot of Cayenne software Wednesday 03/02/2022 at 12:43 PM.

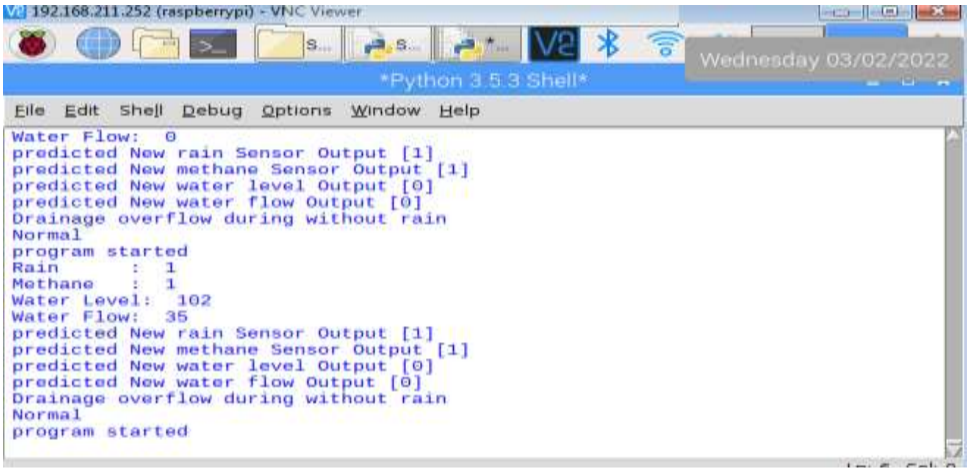

Figure 4. Screenshot of Python Output

The screenshot displays the output as shown in figure 4. It shows the following three condition of underground drainage system of sewer clogging. In general, common situation such as the following has been observed.

Situation 1: Status of the sewer clogging systemwhile heavy rainfall occurs; Water level will be high and the water flow will be high. The water flow is continuous through the drainage system and no blockage detected in the underground drainage system. During this period the motor will be in OFF condition.

Situation 2: Status of the sewer clogging system rainfall does not occur; Water level will be high and water flow does not occur, the underground pipe line detects the block. During this period the motor will switch ON and the block is cleared has the motor gear rod moves forward and reverse. This allows the rotating motor blade to removes the block.

Situation 3: Status of the sewer clogging system while moderate rainfall occurs; Water level will be high and the water flow does not occur but the underground pipe line detects the block. During this period the motor will switch ON and the block is cleared has the motor gear rod moves forward and reverse. The rotating motor blade to removes the block.

Here is the data sheet showing the sensed values for a week 03.02.22 to 09.02.22 recorded as a table observation

DATA SHEET OF SEWER SYSTEM
Observed Readings:

DAYS	RAIN SENSOR	METHANE SENSOR	WATER LEVEL SENSOR	WATER FLOW SENSOR	STATUS OF MOTOR
D1	0	0	30	60	OFF
D2	0	0	31	69	OFF
D3	0	1	66	73	OFF
D4	1	0	111	19	ON
D5	1	1	146	15	ON
D6	0	0	36	78	OFF
D7	1	1	178	12	ON

Status of the Sensors and Motors:

DAYS	RAIN SENSOR	METHANE SENSOR	WATER LEVEL SENSOR	WATER FLOW SENSOR	STATUS OF MOTOR
D1	No rainfall	Minimal gas accumulation	Low level	High	OFF
D2	No rainfall	Minimal gas accumulation	Low level	High	OFF
D3	No rainfall	Considerable gas accumulation	Medium level	High	OFF
D4	Moderate rain	Minimal gas accumulation	High level	Low	ON
D5	Heavy rain	Above normal gas accumulation	Very high level	Very low	ON
D6	No rainfall	Minimal gas accumulation	Low level	High	OFF
D7	Heavy down pour	High gas accumulation	Dangerous level	Very low	ON

On**Day 1** rainfall did not occur, methane gas accumulation was minimal gas formed, the water level was low level but water flow was high. During this situation, the motor was in **OFF** condition.

On**Day 2** rainfall did not occur, methane gas was not formed, the water level was low but water flow was high. During this situation, the motor was in **OFF** condition.

Day 3witnessedno rainfall, but small amount of methane gas was accumulated, while the water level was medium and water flow was high. During this situation, motor was in **OFF** condition.

Day 4 experienced heavy rainfall, methane gas accumulation did not occur, the water level was high and water flow was low. During this situation, the motor switched **ON.**

On **Day 5** rainfall occurred, methane gas accumulated, the water level became high while water flow was low. During this situation, the motor switched **ON**.

Day 6 had no rainfall and was a sunny day, methane gas accumulation was minimal, the water level was low while water flow was high. The motor did not switch **ON**.

On**Day 7** when rainfall occurred along with methane gas formation, the water level was high and water flow was low. During this situation, the motor switched **ON**.

This one-week data of sewer system shows that on **Day 1,2,3,6**no block was detected in the underground drainage system and the motor status was in **OFF** condition**. Day 4,5,7** had block detected the undergrounddrainage system hence the motor switched **ON**. Blocks were cleared by motor gear rod's forward and reverse movements. The rotating motor blades removed the blocks.

Figure 5. Email Notification

The Cayenne software sends the mail notification by using IoT module. When the blockage are detecting and the sensors channels has reached the threshold value of underground drainage system, this system software sending automatic email notification, display on the mobile or monitor and then identifies the clogged spots further actions to be taken by using IoT.

i) WATER FLOW SENSOR

Figure 6 Water flow sensor channel 0 detects the flow of sewer water. Water flow sensor have a valve in which sample water flows. This sensors water flow rate and rotate the rotor rolls in the underground drainage system. If there is a block the flow gets disturbed. whenever the floe stops, the device will be sensing the water flow.

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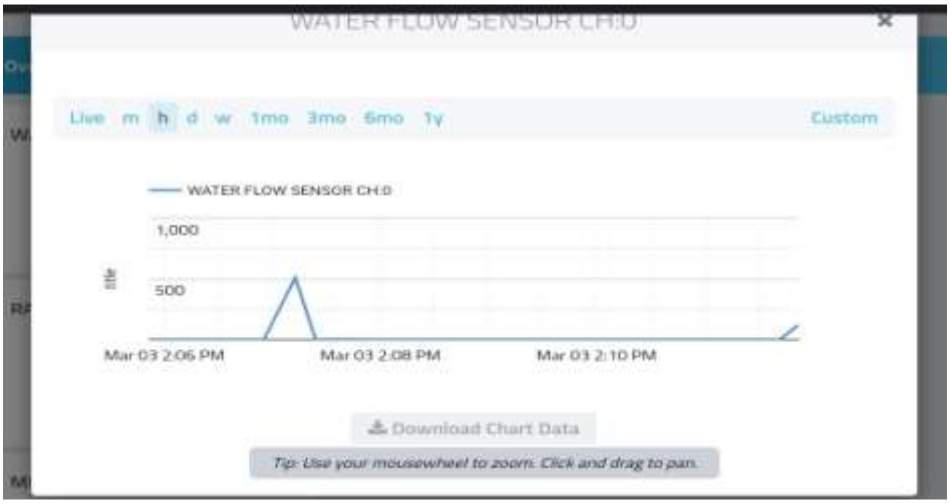

Figure 6. Water Flow Sensor Operation

ii) WATER LEVEL SENSOR

Figure 7Water level sensors channel 1 attached to the top of sewer and connected to device. When there is blockage occur during the water level increased by the chances for sewer overflow. The water level sensor keep up dating the water flow. When the water level reaches a threshold, the system send a message to the mail notification by using IoT module.

Figure 7. Water Level Sensor Operation

iii) RAIN SENSOR

Figure 8Rain sensor channel 2 is a additional sensor which helps to detect the chances of rain. When rainfall occurs there is high chance that sewer gets clogged. The rain sensor can be alert and make precautionary thing before the sewer blockage in the underground drainage system.

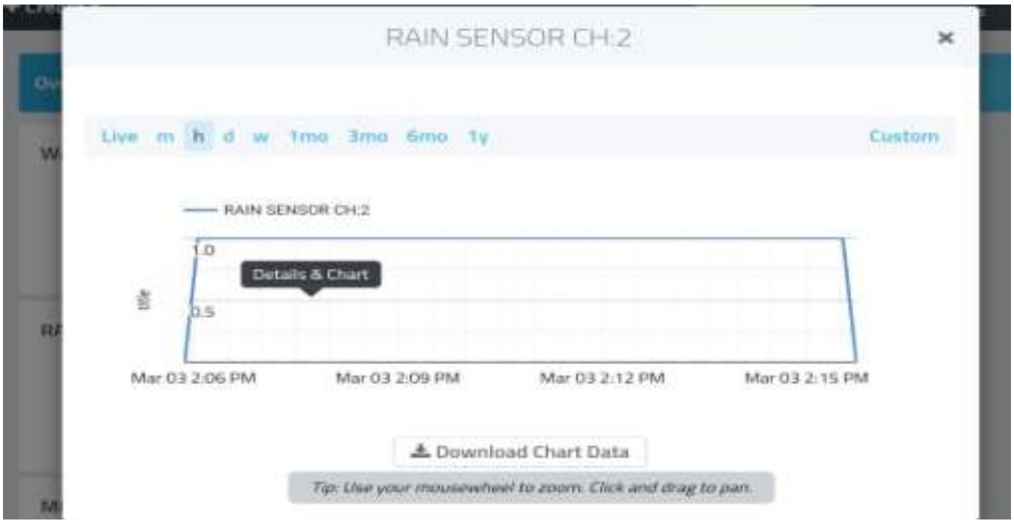

Figure 8. Rain Sensor Operation

iv) METHANE GAS SENSOR

Figure 9 Methane gas sensor channel 3 is used to sense the toxic gases such as methane [CH_4]. This sensor detect the gas formed in the underground drainage system. This sensor will be alert and precautionary thing before the sewer gets gas formed.

Figure 9. Methane Gas Sensor Operation

VII. CONCLUSION

The development of a sensor suite and predictive analytics enabled automatic detection model for smart monitoring of sewer condition is carried out. The automated response, by the system without the need for external intervention would be on-time, less risk prone and more calculated. The proactive action would ensure that the Combined Sewer Overflow (CSO) do not allow overflow as well as there is no reverse discharge of wastewater out of the manhole. After the long-term data collection is done, a proper Machine-learning model could be deployed which would be able to predict the presence of blockage or chances of flood in advance based on various environmental and physical conditions. This robust system will doubly ensure that there no possibility of improper functioning of sewerage system.

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