# SIT 123 Project: Automated Plant Watering and Protection System

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### Problem Statement:

Air pollution is shown to influence a population's subjective well-being [1], especially those in metropolitan areas with fewer plants and nature. Household plants are known to improve air quality which may in turn improve individuals' subjective well-being. However, preserving ideal plant health can be difficult for anyone and it is more common for those who live in metropolitan areas who may have busier lives to struggle to remember to water their plants. Traditional expensive irrigation kits may not provide the level of customization needed for different plant species and environmental conditions; they are also extremely expensive. However, using an Arduino along with some simple items, a cheap automated open-source plant watering and gas monitoring system can be created. This project aims to develop a practical and adaptable solution that automates plant care while promoting healthier and thriving plant life in metropolitan areas. This project also aims to help spread awareness of air pollution but also improve the subjective well-being of those who live in urban areas.

Sense-Think-Act

Sense – The sensor components in this circuit are what identify changes in the environment. This includes the soil moisture sensor measures the water content in the soil and the change in the soil's environment. Similarly, the MQ-5 methane sensor detects gases such as methane and propane in the vicinity of the sensor, the data from both sensors is sent to the Arduino for the next stage of the paradigm.

Think – The Arduino receives all the data that is detected from the sensors and checks the conditions. To elaborate the Arduino receives the soil moisture level reading and checks if it has passed the threshold value of 500. Similarly, the Arduino will also check if the methane levels detected by the MQ-5 sensor are 'HIGH'. The Arduino processes these values and if they meet the requirements a specific action will occur. Under all conditions the Arduino will relay information to the serial monitor which will display the values of the soil moisture and whether methane is detected. As shown below.

```
14:31:22.831 -> Methane Level: Detected  Soil Moisture Level: 371
14:31:23.810 -> Methane Level: Detected  Soil Moisture Level: 297
14:31:24.822 -> Methane Level: Detected  Soil Moisture Level: 124
14:31:25.813 -> Methane Level: Detected  Soil Moisture Level: 145
14:31:26.837 -> Methane Level: Detected  Soil Moisture Level: 177
14:31:27.826 -> Methane Level: Detected  Soil Moisture Level: 190
14:31:28.840 -> Methane Level: Detected  Soil Moisture Level: 353
14:31:29.843 -> Methane Level: Detected  Soil Moisture Level: 354
14:31:30.838 -> Methane Level: Detected  Soil Moisture Level: 266
14:31:31.850 -> Methane Level: Not Detected      Soil Moisture Level: 226
14:31:32.849 -> Methane Level: Not Detected      Soil Moisture Level: 265
14:31:33.849 -> Methane Level: Not Detected      Soil Moisture Level: 327
14:31:34.840 -> Methane Level: Not Detected      Soil Moisture Level: 272
14:31:35.856 -> Methane Level: Not Detected      Soil Moisture Level: 422
14:31:36.859 -> Methane Level: Not Detected      Soil Moisture Level: 27
14:31:37.858 -> Methane Level: Not Detected      Soil Moisture Level: 416
```

Act – The final section of this paradigm focuses on controlling the actuators such as the water pump or buzzer to perform a specific action. This can be done thanks to the Arduino and its IDE, if the soil moisture sensor measures the soil moisture value below the threshold value of 500 it will activate the water pump and continue to pump water until the soil moisture detects the value as being above the threshold. This will halt the water pump, the actions of the water pump are activated or deactivated depending on the soil moisture value. The relay module will provide power to the pump depending on the instructions given by the Arduino. Similarly, the Arduino will instruct the buzzer to activate a high-pitched tone to indicate the presence of methane which is detected by the MQ-5 sensor.

## Hypothesis and Research Issues:

Hypothesis: An automated plant watering and gas monitoring system using Arduino technology can efficiently meet the needs of household plants. Hence resulting in healthier and thriving plants while improving the subjective well-being of those in municipal areas.

Research Questions:

-Is it possible to automate the process of watering plants using an Arduino-based system?

-Can the system accurately monitor and detect the presence of dangerous gases around plants, such as methane?

-In comparison to manual care, how does automation affect plant health and growth?

-What are the cost and advantages of adopting this DIY system over commercial alternatives?

## System Architecture:

The automated plant watering and gas monitoring system is built on the Arduino platform, and it makes use of a variety of sensors and components to provide a versatile and cost-effective solution. The following is a breakdown of the system's architecture.

Arduino Uno – The Arduino is the open-source microcontroller board which is the central component of the circuit. All analog and digital pins for the sensors are attached to the Arduino in their respective positions. Using the Arduino IDE application and its open-source nature, it can run a program and display information or perform actions according to the code.

Breadboard – The breadboard is the construction base in which VCC and GND pins of sensors are attached. This component also works closely with the Arduino as the 5V and GND pins from the Arduino are connected to + and – terminals respectively to provide regulated supply voltage and current to the sensors attached to the breadboard.

Soil Moisture Sensor – This component monitors the moisture level of the soil within the pot plant. The VCC and GND pins are attached to the same row as the breadboards + and – terminals in line with the 5V and GND pins from the Arduino respectively. This provides the sensor power to function, the digital pin of the sensor is attached to D2 on the Arduino and a program code is built to display the soil moisture levels.

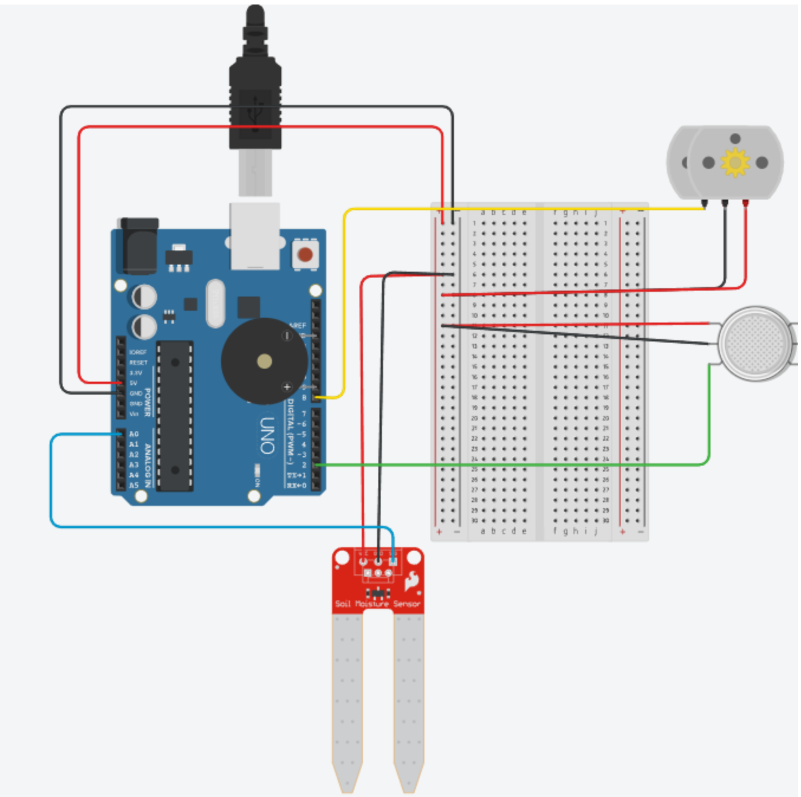
MQ-5 Methane sensor – This component detects methane levels in the atmosphere. When a 'HIGH' level of methane is detected, it will activate the buzzer which is attached to the Arduino, the serial monitor will also display 'Methane Level: Detected'. Like the soil moisture sensor, the MQ-5's VCC and GND pins are attached to the same row of the breadboard in their respective positions.

Buzzer – The buzzer is an indicator that makes a noise when the MQ-5 sensor detects methane in the vicinity. The buzzer is attached directly to the Arduino, the + leg is attached to the D11 pin, and the – leg is attached to the GND pin.

Water pump and relay module – These components work together to provide their function (pumping water from a source into the soil). The relay module is essentially an electrical switch that is turned on and activates the water pump when the soil moisture level is below the threshold of 500. Hence when the soil moisture level is above the threshold it will be turned off. The VCC and GND wires for the pump are connected to one end of the relay module and screwed down, on the other end the respective jumper cables are connected to their positions on the breadboard. The 'IN' pin of the relay module is connected to D8 on the Arduino, this is to enable the Arduino to control the relay module and therefore the water pump by switching the state from HIGH or LOW.

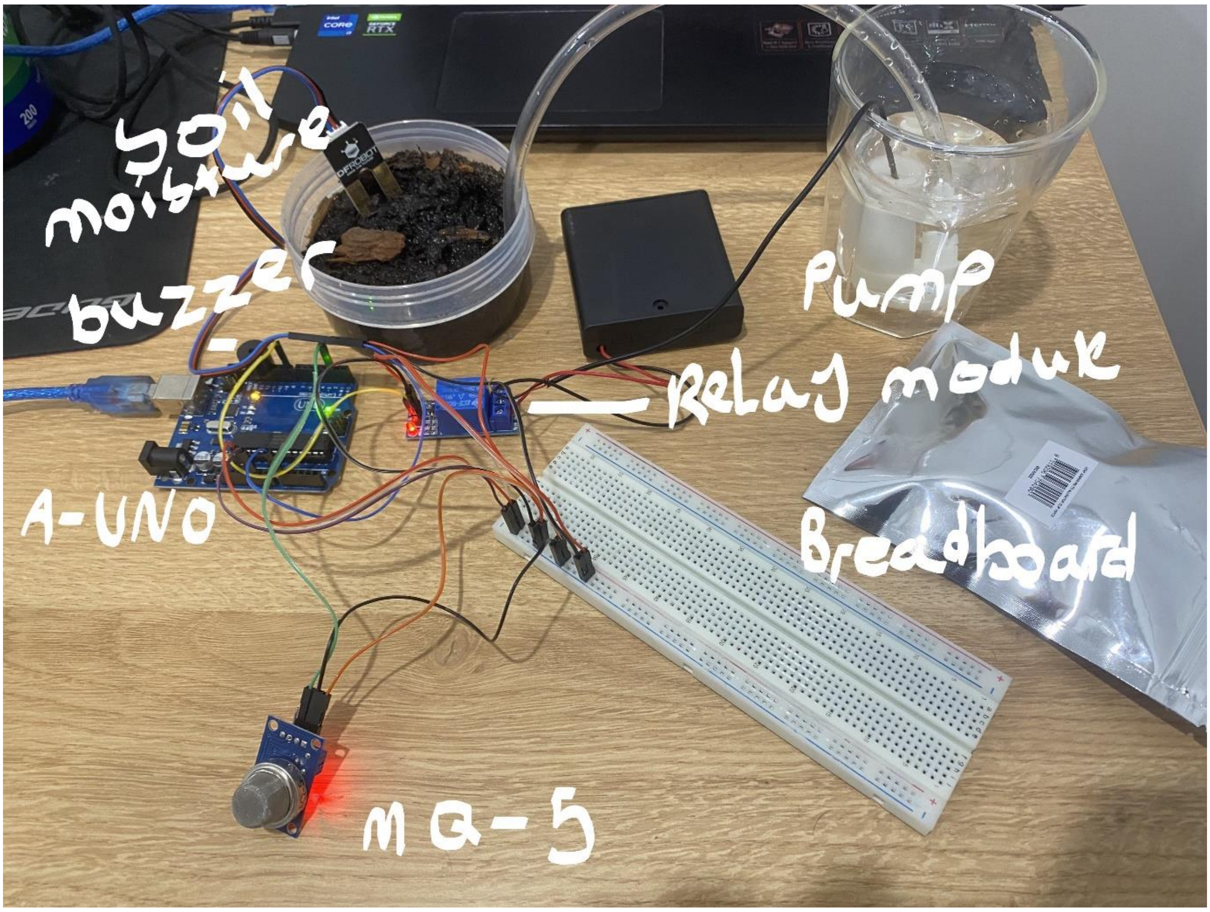
Arduino IDE – This is the software platform used to allow the microcontroller to be programmed to perform our desired actions. This is done by writing code that allows the functionality of the automated plant watering and gas monitoring system, actions are made depending on conditions set in the code.

Tinker cad Diagram:



This visual was created in Tinkercad and is meant to represent the actual setup and its connections. Some components in this diagram differ from the real design. Such as the water pump and relay module being substituted for 2 DC generators because those components aren't available in the modeling tool. The buzzer is also replaced by a piezo for the same reason.

Hardware setup and environment:



## Ethical concerns:

Sense (Collecting Data):

Data Privacy: Although no visual cameras/sensors are used, collecting data from soil moisture and methane sensors can still create privacy problems. Ensure that no personally identifiable information is obtained and that individuals' privacy is maintained. Additionally, no data should be shared with third parties, as the data could fall into unwanted individuals' hands.

Methane Detection: If excessive methane is discovered there is an ethical obligation to notify the appropriate figures about said problem. High methane levels may signal an environmental or safety risk to not only yourself but people in your area whether it is a public workplace or your own home.

Think(Data processing):

Environmental impact/sustainability: Consider the equipment used and the location where the circuit is placed, i.e. is it waterproof, out of reach from kids, animals, etc.... Ensure the circuit placement doesn't harm the environmental surroundings and that the parts will be well-used life cycle-wise, if anything happens to the parts ensure they are recycled correctly.

Act(Outputs):

Efficiency: Because this project uses water to ensure that there is no overwatering, this will reduce waste for this setup.

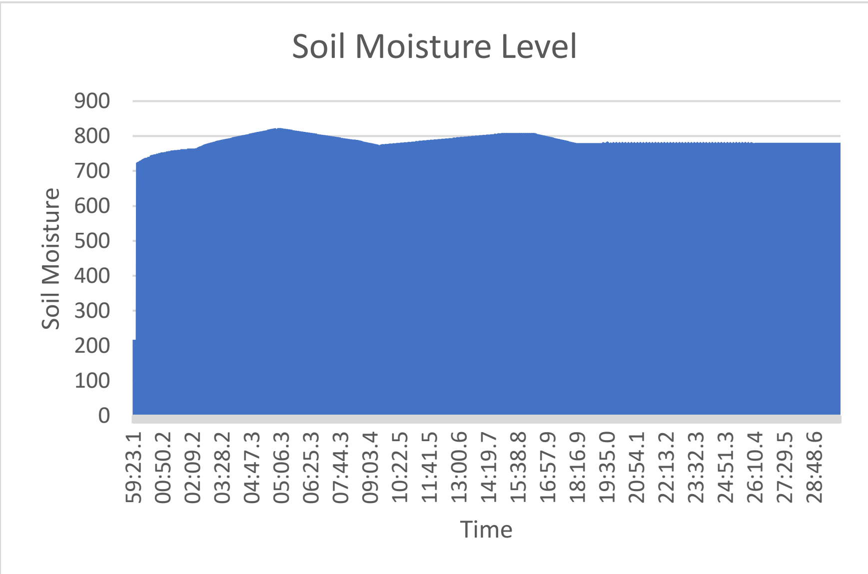
Public: If this project is set up in a public space with others, the buzzer may prove annoying for some. If this is the case the buzzer can be removed or replaced with an LED to indicate the methane levels.

### Data collection process:

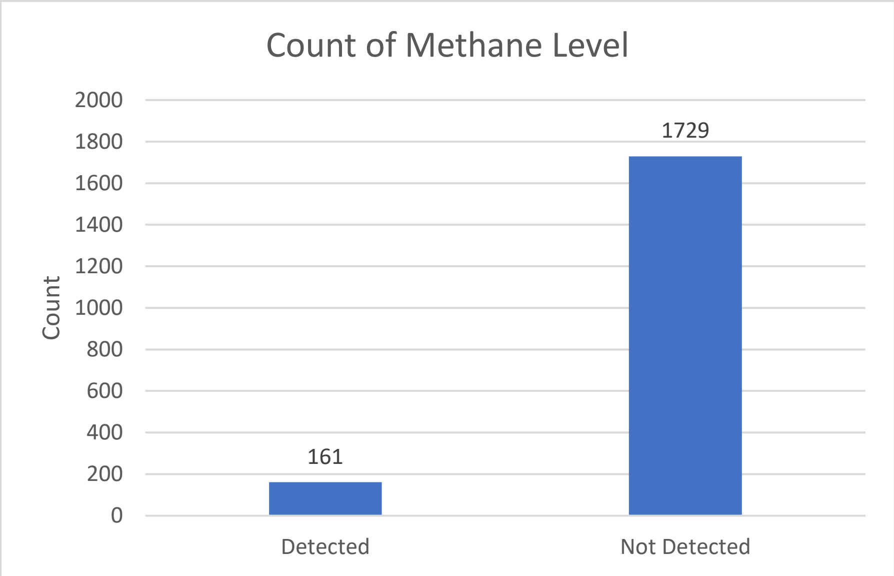
When trying to collect data for this project I had a few issues which I could not get around, the main issue was leaving my computer setup to collect data for multiple days. I couldn't do this as I left the data collection process too late, and I couldn't leave my computer solely to collect data as I needed to bring this computer to my classes across the week. Nonetheless, I decided to collect data over 30 minutes. To start with the pump was turned off and I had just collected some soil and put it into a container, I then turned the water pump on by activating the battery pack attached to the water pump and relay module. The starting soil moisture level was 217, this was before the pump was activated. The way the code is written it is meant to detect and output values on the serial monitor once a second, Hence the pump will stop automatically once the soil moisture sensor detects a soil moisture value greater than 500.

The data was collected from the serial monitor using a terminal feature which allowed me to select all the values instead of manually copying and pasting all the values. I cleaned the data by checking for any null values, double-ups of the same data entry, ensuring that all times were logged, and more.

Using the data from the serial monitor I was able to create a csv file and create these graphs to visualize the data.




This chart shows the rise of the soil moisture level after the water pump was activated. The starting value was 217 and the max value it reached was 823. After reaching its max value it dropped until it slowly increased again before finally decreasing again until it reached a steady flatline around 780-781.




This chart shows how many times methane was detected. As you can see it was detected 161 times out of the entire 30 minutes. When it was detected, the next 2-4 values often indicated that methane was present, meaning that the methane was lingering around the MQ-5 sensor.

### Results Discussion:

My hypothesis stated that using Arduino, an effective plant watering and gas monitoring system can be created which can improve household plant health and potentially increase the subjective happiness of individuals. Although an effective plant watering system was developed, the scale of my hypothesis wasn't met as I didn't have the timeframe to measure plant growth or the subjective happiness of individuals.

Addressing research questions:

-Is it possible to automate the process of watering plants using an Arduino-based system? Yes, in this project I developed an Arduino-based circuit that had an automated watering system. The watering process was also quite efficient.

-Can the system accurately monitor and detect the presence of dangerous gases around plants, such as methane? Yes, this system was able to detect gases such as methane thanks to the MQ-5 sensor. One flaw with the system was that this sensor detects methane, propane, and butane, however, there are no means to differentiate the gases meaning when any of the gases are detected the results will always say "Methane Detected". I used a lighter to test the gas-detecting abilities of the sensor and it proved quite accurate, even at further distances the sensor would eventually detect the combustible gas. Interestingly when the water pump was turned on the serial monitor always seemed to detect methane which may indicate that the pump emits some kind of gas when activated. However, I do not believe it is a harmful amount of gas as no perceivable harm was caused to the soil or plant.

-In comparison to manual care, how does automation affect plant health and growth? The automated plant care system uses sensors and Arduino to determine whether the plant requires water. This is quite useful as it will always deploy water when needed, this eliminates the need for the carer to remember to water the plant manually. However, this all depends on the moisture sensor placement and functionality, hence if an issue arises with the sensor the readings may be invalid which may lead to over or under-watering of the plant. To better understand the effect of automatic plant care it would've been better if my research included 2 plant pots of the same size be studied, one using the circuit I created, and one being manually cared for.

-What are the costs and advantages of adopting this DIY system over commercial alternatives? Reliable commercial automatic plant watering systems can cost upwards of $800, and the cost of the components used in this project amounted to approximately $90. Another benefit of this system is its customisability and extension capabilities, using the Arduino software and purchasing multiple water pumps, soil moisture sensors, etc. you can extend upon this project and customize soil moisture threshold values for each plant's specific needs.

### FUTURE EXTENSIONS:

Remote monitoring could be implemented so that users could receive text notifications about the health of their plants and when they were last watered. This would involve setting up a communication system between the circuit and an external interface such as your phone or computer web application.

Using additional sensors and display outputs a weather station could be created which detects weather and humidity. Using the software, you could also use local weather projections to schedule plant watering, i.e. if it is going to rain, do not activate the water pump as it otherwise oversaturates the plant. This will also reduce environmentally beneficial water waste. Adding temperature and humidity sensors would also improve the overall functionality of the system and prove to be useful in long-term use.

To make this circuit even more environmentally friendly, solar panels could be attached to power the whole circuit. This would also allow the circuit to be placed in more remote/isolated areas, this would work even better if it had remote monitoring capabilities as mentioned above.

Bibliography:


1. Manisalidis, I. et al. (2020) "Environmental and Health Impacts of Air Pollution: A Review", *Frontiers in Public Health*, 8. doi: 10.3389/fpubh.2020.00014.