Science task presentation

1.science plan
1.1(soil sample analysis)

First part of the science plan is based upon collecting the soil sample and sensing the data through all the sensors.

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a)Soil collection assembly

-The rover collects the soil sample using drill assembly which uses an archimedes screw.
(EN8 is used for the manufacturing of screw considering strength, hardness, machinability, cost and availability. It is a popular grade unalloyed medium carbon steel readily machinable in all conditions.)

- The rover anchors itself in the ground while a drill lowers and begins to drill into the soil. 10-20 gm of soil from 5cm deep is brought up to the surface, and collected inside the container.

- A rotating mechanism is designed to collect the soil sample in 4 different compartments of a single container to perform various tests and operations for data analysis.
(The container is made up of ABS which is a thermoplastic polymer with high Chemical Resistance, Excellent High and Low Temperature Performance, great electrical insulation properties.)

b)Design assembly

-Design assembly consists of driller system which is controlled by dc motor for soil collection*.*

-Rotating soil container system is controlled by another motor, the container is rotating with the help of plate attached with a gear. *The system is provided with lid screw mechanism which converts rotational motion of container plate to upward linear motion to kept the machinery well above ground when not in use.*

1.2(Atmospheric analysis)

second part of the science plan is based upon analysing the atmosphere and sensing the data through all the sensors.

- Analysis of various gases(like green-house gases) present in the atmosphere using gas sensors.

- Analysis of various atmospheric parameters such as atmospheric pressure, temperature, relative humidity

- Analysis of radiation level present at the given geographical area. (particularly we are detecting the levels of ultra-violet , infrared and visible light in the site).

1.3(topographic analysis)

third part of the science plan is based upon understand the topography of land surface by determining the configurations of the land surface, overall shape and size of the selected site, its aspect *(position with respect to compass coordinates). We have determined :*

1. shape and size of site
2. GPS coordinates
3. Cardinal directions
4. elevation level of each site

2. Sensors

a)CJMCU-8128

Description

This sensor consists of three other sensors named:-

CCS811 *(which can provide equivalent level of carbon dioxide and total volatile organic compounds(TVOC) index.*

HDC1080*(The HDC1080 is a digital humidity sensor with integrated temperature sensor that provides excellent measurement for relative humidity and temperature).*
BMP280 (it is an absolute pressure sensor and also altitude levels).

Working

*The **CCS811** is an low power digital gas sensor solution which integrates a metal oxide (MOX) gas sensor for monitoring gas concentration in air , CCS811 supports intelligent detection algorithms to process raw sensor measurements to represent equivalent CO2 levels or TVOC measurement in real world environments.*

*Sensing element of the **HDC1080** is placed on the top part of the device. Measurement results read through the I2C interface where it act as slave device. Resolution is based on the measurement time and can be 8, 11, or 14 bits for humidity;11 or 14 bits for temperature.*

***T*he temperature register is a 16-bit result register in binary format(the 2 LSBs D1 and D0 are always 0). The result of the acquisition is always a 14 bit value.**

Temperature(‘c) = [TEMPERATURE(15:0)/2exp(16)]*165-4

The humidity registeris a 16-bit result register in binary format(the 2 LSBs D1 and D0 are always0). The result of the acquisition is always a 14 bit value.

Relative Humidity(RH) = [HUMIDITY(15:0)/2exp(16)]*100

The **BMP280** is an absolute barometric pressure sensor. It is housed in an compact 8-pin metal-lid LGA package with footprint of 2.0x2x0.95mm package. Its small dimensions and low power consumption of 2.7µA@1Hz allow the implementation in battery-driven devices such GPS modules, It supports both I2C and SPI.

Data analysis

This sensor gives 6 values and we are using ROS message (Twist) to publish all 6 values

1) atmospheric pressure(in mm Hg) – linear(x)
2) Altitude (in m) – linear(y)
3) Temperature(in C) – linear(z)
4) Relative Humidity – angular(x)
5) CO2 value(in ppm) – angular(y)
6) tVOC value(in ppb) – angular(z)

Reason to use

Temperature has been found to affect the living organisms in various ways, it has significant role on the **cells**(If too cold, cell proteins may be destroyed as ice forms),**metabolism**(metabolic activities of microbes are regulated by varied kinds of enzymes which are influenced by temperature, consequently increase in temperature, upto a certain limit, brings about increased enzymatic activity, resulting in an increased rate of metabolism) **life distribution**(optimum temperature for the completion of the several stages of the life cycle), **growth**(growth rates of different species is also influenced by temperature).

Atmospheric pressure determined by no. of air molecules above the surface, it determines the amount of gases dissolve in atmosphere, without atm. pressure intermolecular forces will be insufficient to hold water molecule in liquid form and it would evaporate away, hence no life possible.(on Mars, which has a very low air pressure and where the surface is extremely dry but there are indications that there are underground supplies of water.)

Humidity plays an important role for surface life. Species dependent on perspiration to regulate internal body temperature, high humidity impairs heat exchange efficiency by reducing the rate of moisture evaporation from skin surfaces.

Correlation with mars

The **temperature** on mars is much colder than on earth, on average it ranges from about (-60c) to (80c). Frost forms on the rocks at night, but at morning the air gets warmer, the frost turns to vapor, and there is 100 percent humidity until it evaporates. **Humidity** of Mars is tied to temperature fluctuations and the high humidity could help make Mars more habitable, if the water condenses to form puddles in the early morning hours and life could sustain by poaching water from humid air. Water vapor is a trace gas in the Martian atmosphere and has huge spatial, diurnal and seasonal variability.

Mars is known to have several significant topographic features such as Olympus Mons, the highest peak in the solar system, and Valles Marineris, a canyon that easily dwarfs the Grand Canyon. The difference between Mars highest and lowest points (**altitude** levels) is nearly 30 km.

Mars atmosphere is thin relative to earth's surface(due to presence of solar winds and low magnetic field value), its **atmospheric pressure** value is about 6 mbar(4.5mm Hg) whereas that of earth is 1013 mbar(759.8mm Hg). It varies with elevation as well as season(it happens due to change in amount of CO_2 gas in the atmosphere with the seasons).

b) ***Spectrophotometer sensor(AS7265x)***

Description

Spectrophotometer sensor which uses radiation from three different regions of electromagnetic spectrum (infrared, visible and ultra-violet region) to illuminate and test various surfaces for light spectroscopy and 18 individual light frequencies can be measured.

Working

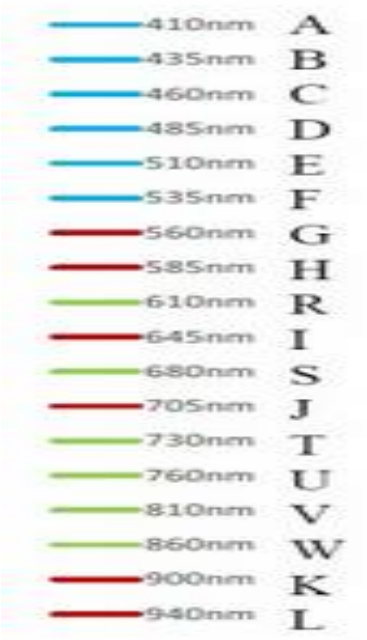
The triad is made up of three sensors AS72651 (UV), AS72652 (VIS), and AS72653 (NIR). The AS72651 communicates with the x2 and x3 sensors over a dedicated I^2C bus (the AS72651 is the master, the AS72652 and AS72653 are slaves). The AS72651 combines its sensor data with the data from the x2 and x3 sensors and exposes the datums to the user as a single array of registers.

The triad contains a 5700k white LED, a 405nm UV LED, and a 875nm IR LED mounted alongside the sensors. These LEDs were chosen to illuminate the target(1-2 inch away) with the largest swath of visible and invisible light.

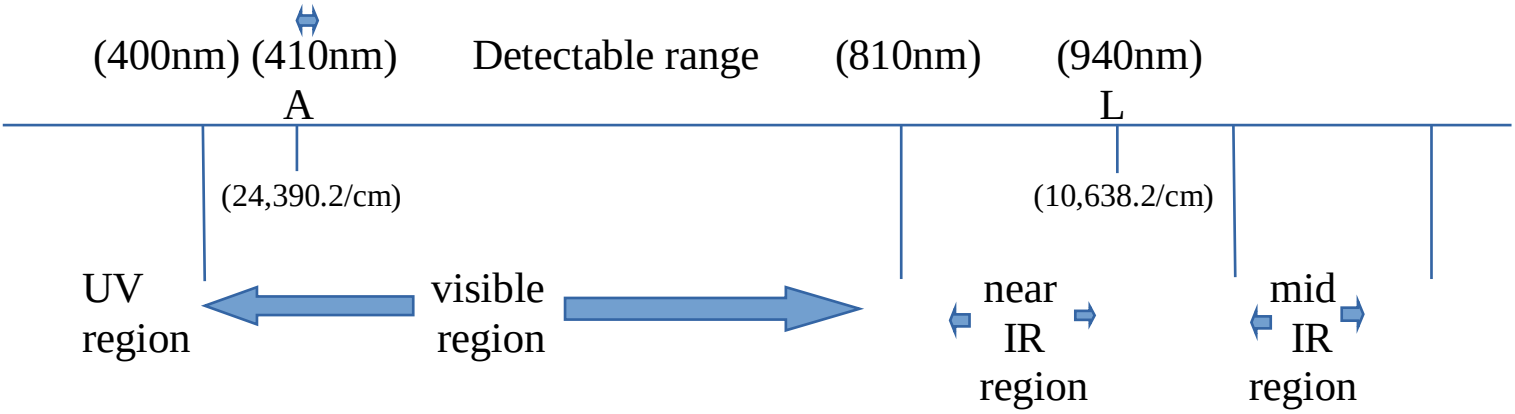
It works on the principle of emission spectroscopy in which the radiation impinges to the substance and atoms makes transition from high energy to low energy state and each transition has a specific energy difference which corresponds to a particular wavelength forming an emission spectrum and we can detect the presence of various minerals and nutrients from peak values of emission spectrum.

Data Analysis

In emisson spectrum a graph is plotted between wavelength and intensity values at different wavelength and the presence of elements/compounds detected from peaks corresponding to a particular wavelength.



- alphabets(A,B,C,D,E,F,G,H,R,I,S,J,T,U,V,W,K,L) are used for designation of different wavelength values ranging from (410nm-940nm) [this values are plotted in x-axis]
- intensity values corresponding to each wavelength plotted. [this values are plotted in y-axis]



different wavelength of some important elements/compounds:

1) sodium(Na): 589.5nm-588.9nm
2) potassium(K): 766.5nm
3) magnesium(Mg):285.2nm
4) chlorine(Cl): 256.4nm-307.4nm
5) oxygen(O) : 760nm-763nm
   dioxygen ion(O2+) : 495.9nm-500.7nm
6) iron
7) nickel(Ni1): 508.11nm and 778.89nm , (Ni2):337.89nm
8) sulphur(S): 394nm
9) phosphorus(P):200-360nm, (PO1):320-360nm and (PO2):230-280nm
   (PHO):526nm

10) calcium(Ca): 422.7nm, (Ca2+):500nm
11) chromium(Cr): 427.4nm
12) titanium(Ti): 650nm-656.5nm
13) aluminium(Al1): 396.2nm and (Al2):466.4nm
14) silicon(Si1): 478.2nm,568.4nm and 633.1nm
15) manganese(Mn2+): 510nm-550nm
16) boron(B): 550nm-570nm(imp)
17) chlorides: 585nm-612nm
18) carbonates:190-390nm(Carbonates, predominately $MgCO_3$, have been spectroscopically identified at a level of 2-5% in martian dust.)
19)nitrates: 220nm-300nm
20)nitrites: 350nm
21) proteins: 350nm
22) lipids: 345nm and 375nm
23) carbohydrates[lactose: 425nm and 450-460nm]
24) nucleic acids[DNA:525nm and RNA:530-535nm]

Reason to use

-Bulk elements such as (oxygen, carbon, hydrogen, nitrogen, and sulphur), along with macro-minerals (sodium, magnesium, potassium, calcium, chlorine, and phosphorus) are important for biological survival.

-presence of boron stabilizes the sugar ribose which is an ingredient in RNA. Ribose would rapidly decompose in water without *boron so necessary for life to form.*

-One way to infer is to check whether water had flown through the soil in the past. This could be detected by testing for the presence of certain compounds in the soil such as sulphate, chloride, carbonate, nitrate, nitrite, iron, calcium, magnesium.

-Nitrate and nitrite in the soil is indication of presence of the bacteria in the soil.

-Biomarkers such as proteins, lipids, carbohydrates, nucleic acid are vital for every single organism. Without any of these molecules, a cell and organism would not be able to live.

Correlation with mars

The planet's mantle contains large amount of iron (which gives red color to soil), it's also rich in sulphur, potassium, phosphorus and contains higher percentage of volatile elements such as sulphur and chlorine.

Magnesium, aluminium, calcium, and potassium are major components of igneous rocks. The dust soil consists of titanium, manganese, chromium, chlorine.

Carbonate is a very important mineral and tells about whether there was enough carbon dioxide vapor to warm Mars's early atmosphere. It forms when water traps atmospheric CO2(carbonates, predominately MgCO3, have been spectroscopically identified at a level of 2-5% in martian dust.)

Presence of boron was discovered in 2016 that shows there have been temperature between 0-60 degrees celcius and a neutral-to-alkaline pH which supports habitable environment.

Stress marker is used to detect whether species is capable of growth and this

can be found in lipids, When cells are exposed to stressful conditions, their lipids change structure, becoming more rigid.

Dating of dead cells can be found with the help of amino acids since it creates two forms which are mirror reflections of each other. All live forms are left handed forms but when species die it creates right handed form and by looking on these ratio its dating can be done.

c)Gas-sensors(MQ-4,8,9)

Description

MQ gas sensors are used to detect the presence of gases in atmosphere. The srtructure and configurations of most of these gas sensors are almost similar and they consists of ceramic tube(AL_2O_3), a sensitive layer(SnO_2), measuring electrode and heater fixed into a crust made by plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive components. The enveloped MQ-sensor have 6 pin ,4 of them are used to fetch signals, and other 2 are used for providing heating current.

MQ-4- methane gas sensor
MQ-9- carbon monoxide gas sensor
MQ-8- hydrogen gas sensor

Working

There exist two resistances load resistance(R_L) and sensor resistance(Rs) and these forms a voltage divider, output voltage(Vo) can be read by arduino. For particular (Vs=5v, Vo, R_L) we can calculate (Rs). First we calibrate the MQ-sensor by calculating (Rs) at clean air (Rs=Ro) which gives a fixed value then, we calculate sensor resistance(Rs) at different concentration of gas . Then we calculate the ratio(Rs/Ro) and from the graph between (Rs/Ro) vs ppm, we calculate the corresponding point of gas concentration(in ppm) value and its percentage composition in atmosphere.

Data analysis

All the three sensors gives 2 values(concentration and percentage composition) in total 6 values so we are using ROS message (Accel) to publish all 6 values.

1) MQ-4 methane concentration(in ppm) – linear(x)
2) MQ-4 methane percentage composition– linear(y)
3) MQ-9 carbon-monoxide concentration(in ppm) – linear(z)

4) MQ-9 carbon_monoxide percentage composition– angular(x)
5) MQ-8 hydrogen concentration(in ppm) – angular(y)
6) MQ-8 hydrogen percentage composition – angular(z)

Reason to use

- **Greenhouse gases** are certain molecules in the air that have the ability to trap heat in the Earth's atmosphere. Some greenhouse gases, like carbon dioxide (CO_2) and methane (CH_4), occur naturally and play an important role in maintaining warm climate for life sustainability.
(mono-atomic gases like Ar don't have vibrational modes and molecules of same atom like N_2, O_2 on vibration by IR radiation do not have net charge distribution so they are not greenhouse gases. Some molecules containing just two atoms of different elements, such as (CO), (HCl) do absorb IR radiation, but these molecules are short-lived in the atmosphere.)

- Hydrogen is the most abundant element in the universe and most of the hydrogen is in the form of chemical compounds such as water and hydro-carbons(they are the basic units of biomolecules useful for functioning of living organisms).

- VOCs play an important role in communication between plants, and messages from plants to animals.

Correlation with mars

- study from curiosity rover reveals asteroid impacts on ancient mars could have produced scope for life(producing nitrates and nitrites) if the martian atmosphere was rich in hydrogen, since presence of hydrogen led to a faster cooling of the shock created by collision, trapping nitric oxide and increases nitrate levels.

-The atmosphere of Mars is about 99 times thinner than Earth's, and it is 95 percent carbon dioxide but it is extremely thin (1% of Earth's atmosphere), very dry and located further away from the Sun. This combination makes the planetan incredibly cold place(increasing the amount of greenhouse gases and thickening the atmosphere may terra-form the surface to a habitable climate)

-Sample Analysis at Mars (SAM) instruments dropped the rover in Gale crater and collected various VOC such as chlorobenzene and dichloro-alkanes and presence of these helps in photochemical analysis to support biological life.

d) ***Soil-moisture sensor(EC-1258)***

Description

this is a digital soil moisture sensor which consists of two probes need to be inserted on soil and it can can measure moisture level content in it. The sensor includes a potentiometer to set the desired moisture threshold. The digital output can be connected to an arduino to sense the moisture level. The sensor also outputs an analog output which can be connected to the ADC of a micro controller to get the exact moisture level in the soil.

Working

The Soil Moisture Sensor uses capacitance to measure dielectric permittivity of the surrounding medium. In soil, dielectric permittivity is a function of the water content. The sensor creates a voltage proportional to the dielectric permittivity, and therefore the water content of the soil. The sensor averages the water content over the entire length of the sensor. The Soil Moisture Sensor is used to measure the loss of moisture over time due to evaporation.

Data analysis

Soil moisture sensor only gives the percentage moisture content of the soil sample. We are using the ROS message (quaternion) as part of it to output moisture percentage.

Soil moisture content(percentage value): x

Reason to use

-moisture remains in the *soil* as a thin film, s*oil* water dissolves salts and makes up the *soil* solution, which is *important* as medium for supply of nutrients to *growing* plants.

-it is a key factor in controlling the exchange of water and heat energy between land surface and atmosphere.

Correlation with mars

- Curiosity's Sample Analysis at Mars (SAM) performed tests to heat up the soil sample and then measures the gases that emerge, the most common gas released (between 1.5% and 3% by weight) was water vapour per cubic foot of Mars soil. Most of the water on Mars today exists as ice, though it also exists in small quantities as vapour in the atmosphere.

-Exploration and reconnaissance missions sent by NASA to Mars, as old as Mariner 9 and the Viking Mission in the 70's, have already collected evidence of water flowing on the surface, which can be observed by the formation of soil erosion patterns

e) ***pH and conductivity sensor***

Description

This sensor is specially used to measure the electrical conductivity and pH of soil sample. It consists of laboratory grade glass probe tip, Signal Conversion Board (Transmitter) V2, a BNC connector connecting transmitter board and probe. It supports 3-5v wide voltage input, and is compatible with 5V and 3.3V main control board. The excitation source adopts an AC signal, which effectively reduces polarization effect and improves the precision.

Conductivity is the reciprocal of an objects resistivity, which is related to the ability of the material to carry the current and pH stands for power of hydrogen, which is a measurement of the hydrogen ion concentration in the sample.

Working

For **conductivity**, the probe is calibrated for its first use using standard buffer solutions of known conductivity to be able to operate in two point calibration. Once the sensor is calibrated first it can be used with any sample to test for the conductivity value.

For **pH**, the probe is individually calibrated with the different analog values obtained from the probe tip with the standard pH values of different samples. Once this was done, it can be used with any sample to measure the pH value.

Data analysis

Conductivity part of this sensor gives the conductivity value(in ms/cm) of the soil sample. Whereas the pH part of these sensor gives the pH value of the soil sample. We are using the ROS message (quaternion) as part of it to output the two values.

Soil conductivity (in ms/cm): y
Soil pH value: z

Reason to use(soil salinity, tds, CEC)

-Soil electrical conductivity (EC) is a measure of the amount of salts in soil (salinity of soil). It is an important indicator of soil health. It has been correlated to concentrations of nitrates, potassium, sodium, chloride,

sulfate, and ammonia. For certain non-saline soils, determining EC can be a convenient and economical way to estimate the amount of nitrogen (N) available for plant growth.

-Soil pH is important because it influences several soil factors affecting plant growth such as soil bacteria, nutrient leaching, nutrient availability, toxic elements, and soil structure the relative acidity or alkalinity of soil is indicated by its pH.

Correlation with mars

-The electrical conductivity probe was mounted on the phoenix lander to conduct in-situ measurements of the exchange of heat and water in the martian polar terrain. It was used to determine the thermos-physical properties that control energy fluxes atmosphere and sub-surface to characterize the processes that control the distribution and exchange of water between atmosphere and sub-surface in current climate and to detect the presence of any unfrozen water.

- The Phoenix lander returned data showing Martian soil to be slightly alkaline and containing elements such as magnesium, sodium, potassium and chlorine, which are necessary for growth of plants.

f) ***Luminosity(TSL-2561) and UV-intensity sensor(GUVA-S12sd)***

Description

The TSL-2561 luminosity sensor breakout is a sophisticated light sensor which has a flat response across most of the visible spectrum. It measures both infrared and visible light to better approximate the response of the human eye in lux(lumens per metre and it measures how bright any given illumination will appear to the human eye) which is a very complex measurement to make because it involves both the human eye's response to colour (frequency) and the concentration of that light.

It uses a UV-photodiode, which can detect the 240-370nm range of light (which covers UVB and most of UVA spectrum). The signal from the photodiode is very small level, in nano-ampere level, hence an op-amp used to amplify the signal to a more manageable volt-level.

Working

-To use, we power the sensor and op-amp by connecting to 5v VDC and GND to power ground. Then we read the analog value from the pin and we compare the analog value with the UV-index table to calculate UV index value.

-We connect four of the five pins on the board to the Arduino. The four pins we need are labelled **3V3**, **GND**, **SCL**, and **SDA**. The TSL2561 communicates with a host microcontroller via I2C communication. We collect the analog values and convert the input values into lux values through mathematical calculations.

Data analysis

-luminosity sensor only gives the luminosity values in lux. We are using the ROS message (quaternion) as part of it to output luminosity value in lumen/m.
Luminosity value (in lux): y

-UV intensity sensor gives the UV-index value. We are using ROS message (Float32) to output the UV-index value of the atmosphere.
UV index value: uv

Reason to use

-extreme low radiations are harmful all organisms have cellular repair and response mechanisms that can keep adverse health effects from occurring and it inhibits the growth of species.
High **radiation** can affect the atoms in **living** things, so it poses a health risk by damaging tissue and DNA in genes and it has sufficient energy to affect the atoms in **living** cells and thereby damage their genetic material (DNA).

Correlation with mars

-Mars has no protective magnetosphere its atmosphere was slowly stripped away by solar wind. Due to the loss of its magnetic field and its atmosphere, the surface of mars is exposed to much higher levels of radiation in addition to regular exposure to cosmic rays and solar wind, it receives occasional lethal blasts that occur with strong solar flares.

3.conclusion

soil sample analysis

a)soil composition analysis

-presence of bulk elements (oxygen, carbon, hydrogen, nitrogen and sulphur), and macro-minerals (sodium, magnesium, potassium, calcium, chlorine, and phosphorus) are important for biological survival.
-presence of boron necessary for life to form since it stabilizes the sugar ribose which indicates presence of RNA.
-presence of certain compounds in the soil such as sulphate, chloride, carbonate, nitrate, nitrite, iron, calcium, magnesium indicates whether water had flown through the soil in past.
- Nitrate and nitrite indicates the presence of the bacteria in the soil.
- Biomarkers such as proteins, lipids, carbohydrates, nucleic acid are vital for every single organisms.

b)soil erosion pattern

-presence of high values of soil moisture increases the soil compactness thus creating lumps which loosens the top-soil allowing small fragments to detach and it increases the soil erosion
-It also depends on the topography of the surface, if the land is sloped there is a greater potential for soil erosion and soil materials moves down the slope.

c)soil moisture

-presence of moisture in soil indicates the presence of dissolved salts makes up the *soil* solution and it supplies the nutrients to *growing* plants. It is a key factor in controlling the exchange of water and heat energy between land surface and atmosphere.

d)Soil salinity and electrical conductivity

-detection of soil electrical conductivity (EC) measures the amount of salt in soil (salinity of soil). It is an important indicator of soil health. It has been correlated to concentrations of nitrates, potassium, sodium, chloride, sulphate, and ammonia. For certain non-saline soils, determining EC can be a convenient and economical way to estimate the amount of nitrogen (N) available for plant growth.
[High EC value - saline soil]
[Low EC value - non saline soil]

e)cation exchange capacity(CEC)

-The cation exchange capacity of soil is related to the amount and type of clay and organic matter content in the soil and it is correlated with the values of electrical conductivity.
[High EC value – high CEC]

[Low EC value – low CEC]

f)Soil pH

-we detected the soil pH since it influences several soil factors affecting plant growth such as soil bacteria, nutrient leaching, nutrient availability, toxic elements, and soil structure and the relative acidity or alkalinity of soil is indicated by its pH.

g)Sub soil temperature

-We detected the soil temperature directly since it affects the plant growth. Germination of various seeds requires different soil temperature ranges. Soil temperature influences aeration, soil moisture content, and the availability of plant nutrients.

Atmospheric analysis

a)Atmospheric temperature

-We determined the atmospheric temperature value since it has significant role on the **cells** (If too cold, cell proteins may be destroyed as ice forms), **metabolism** (increase in temperature, brings about increased enzymatic activity, resulting in an increased rate of metabolism) **life distribution** (optimum temperature for the completion of the several stages of the life cycle), **growth** (growth rates of different species is also influenced by temperature).

b)Atmospheric pressure

-We determined the atmospheric pressure value, since it determines the amount of gases dissolve in atmosphere, without atm. pressure intermolecular forces will be insufficient to hold water molecule in liquid form and it would evaporate away, hence no life possible.

c)Relative humidity

-We determined the relative humidity since it plays an important role for surface life. High humidity impairs heat exchange efficiency by reducing the rate of moisture evaporation from skin surfaces.

d)Green-house gases

-we detected the presence of green-house gases (CO_2, CH_4) because they play an important role in maintaining warm climate for life sustainability.

e)Hydrogen gas

-We detected the presence of hydrogen since it is the basic constituent of chemical compounds such as water and hydro-carbons(they are the basic units of biomolecules useful for functioning of living organisms).

f)tVOC levels

-We detected the presence of total volatile organic compounds since it plays an important role in communication between plants, and messages from plants to animals.

g)Radiation levels

-We determined the presence of UV and IR radiation since extreme radiation conditions are harmful (low radiation impacts cell growth) and (high radiation affects the atom in living things by damaging tissues and altering DNA).

Topographic analysis

a)shape and size of site

-We analysed the field site using LIDAR to form a 2D-mapping of the task site.

-We analysed the task sites using wide angle panoramic view.

b) GPS coordinates

c) Cardinal directions

d) elevation level of each site

-We determined the elevation levels of various task sites to predict the geography of surface since it entails the delineation and characterization of regions on Mars.

(The **geography of Mars**, also known as **areography**, entails the delineation and characterization of regions on Mars. Martian geography is mainly focused on what is called physical geography on Earth; that is the distribution of physical features across Mars and their cartographic representations.)