GROUND WATER AND SALINITY LEVEL DETECTION USING SWARM ROBOTICS

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ABSTRACT *The traditional underground water survey method often consumes excessive manpower for determining underground water levels. In terms of underground water detection the drilling method is most commonly adopted method which is both labour exhaustive and high material exploitative. Existing autonomous robots that detects ground water status are of high expense and large in size. This project focuses on checking the status of underground water and salinity level in large areas where manual labour might be extensive and time consuming autonomously by implementing Ground Penetrating Radar (GPR),Common Mid Point (CMP) and Vertical Electrical Sounding (VES) methods using bots. The vacant land is being investigated using Swarm Robotics by implementing these methods, each robot coordinate with each other by collecting the data and images. Swarm robotics are meant for miniaturization and cost effective. The nature of swarm robotics is to coordinate with each other and completes a task effectively compared to an individual machine. This allows the workload to be divided hence lessening the size of the system. Also adds the automation of the system, thus lowering the need for manual work. Each robots are assigned with above mentioned methods that coordinate with each other as well as with the main system that gives the clarity picture of presence of water whose location is later sent to the swarm, autonomously that depicts the salinity level. Thus from the data compiled ,images generated and by implementing VES method along with Swarm Robotics, this study finds the groundwater status efficiently.*

Keywords: *Ground Penetrating Radar (GPR),Common Mid Point (CMP) and Vertical Electrical Sounding (VES), Swarm Robotics, Coordination.*

I. INTRODUCTION

Irrigating a crop can be implemented by various source of water. The most traditional and effective way is by nature which is underground water which are less polluted than surface water. The standard of the available water must be tested to check its fitness prior to use. Groundwater are replenished by natural rain and snow melts that exude into the crevices or fissures underneath the earth surface. But, farmers usually face major water shortages because of high consumption of underground water than it is naturally recharged. In other areas groundwater is highly polluted by human activities. In general, groundwater is recharged or accumulated everywhere but locating it is tricky . The groundwater table may change depending on many major factors. The occurrences of heavy rains or snow melting may increase the groundwater table , or external pumping of groundwater supplies may decrease the water table . Groundwater is highly utilized to irrigate crops. Almost 63% of ground water is used for irrigation. Various methods and machines have been incorporated for detection of underground fresh water. The non-destructive characteristics of GPR along with CMP have demonstrated to be very useful for geotechnical application. Equipment involved for detection are basically heavy because of the involvement of different methods in detections. These machines survey the field all by itself which is exhaustive. Swarm robotics by nature has the characteristics of coordination and interaction between several robots as a system that solves large tasks which are simplified to miniature. The technique lets robots communicate with each other by interchanging the collected locations through wireless medium among the swarm. Location of each robots is sent to each other as well as to the main system through algorithms that find shortest path in cluttered environment. The working of GPR is by transmitting radar wave of 10-2500 MHz through transmitting antenna pointing toward the ground constantly in very rapid velocity. It consists of transmitting antenna that send a radar whose conductivity or dielectric constant changes when interacts with an interface or object under the electromagnetic characteristics, a partial radar is reflected to the ground surface which is received by receiver antenna. The image that is collected through is radar is later displayed in the main system. After numerous processing and plotting, the position of the water was determined. This location is later sent to the swarm that surveys the level of salinity in water by implementing the VES method. VES method provides useful information to farmers regarding ground water salinity and is also cost-benefit approach on conducting survey on farms land. The VES method uses two current electrodes that are penetrated into the ground. Basic electrode configurations used are pole-dipole, dipole-dipole, Wenner and Schlumberger. Most effective configuration is Schlumberger. The electrodes are spaced for different lengths and respective resistivity are obtained which is later plotted and compared with the Fitness for irrigation (FFI) classification table to determine the fitness of water for irrigation.

II. PLAN OF ACTION

A PHASE 1

A swarm unit that detects the groundwater using Ground Penetrating Radar(GPR) method in different location of the farm. This unit sends the received signal back to the monitor that displays the wiggle diagram.

B PHASE 2

Units of swarm that improves the creditability of the section using Common Mid Point(CMP) after receiving the location of the water level from the previous swarm.

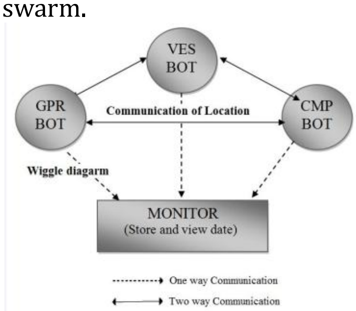

Fig 1 : Architecture of the system

C PHASE 3

Checking the salinity level of water detected previously, for the feasibility for irrigation by applying the Vertical Electrical Sounding(VES) method. This phase calculates the EC and VES resistivity values.

D FINAL PHASE

The estimated EC and VES resistivity values are compared in the monitor to find the location that has feasible level of water for better improvement of irrigation.

III. MATERIALS AND METHODS

A. Role of Swarm Robots

Swarm bots are miniature robots that are designed to perform major time taking tasks by dividing into minor modules. Each robots function distinct tasks individually by coordinating and interacting with each other. This project consists of three modules and a main system. Three swarm bots survey the land using three methodologies that are described in detail later. The GPR bot detects the location of the groundwater availability and also collects the wiggle diagram which is later sent to the monitor. The CMP bot collects the location from the GPR bot to remove the noise signals from the image collected. Further, the VES bot gets the location from the previous bot and detects the salinity level and send the data to the monitor for further investigation. The main advantage of swarm bots is its cost-effective and feasible.

B. Swarm of GPR(Ground Penetrating Radar)

Ground penetrating radar is a geophysical measurement technique that has been extensively applied for gauging the thickness of ice layers, mining, underground water level, soil interface, underground cavities, faults and layer texture at scales from kilometres to centimetres. The technique involves image processing and location retrieval which is similar in principle to seismic, one antenna, the transmitter. The presence of small quantity of water underneath the surface influences the behaviour of the dielectric permittivity in a fluid system. The swarm bot consists of a transmitting antenna, a receiving antenna, a control unit and the main system consists of a graphic recorder to display the data and an analog or digital tape recorder to store and process the collected data. The GPR method functions by transmitting a electromagnetic wave beneath a specific location. Changes in the dielectric properties is observed if the radar gets in contact with an obstacle. This radar is reflected to the receiver antenna. The recorded signal is sent back to the monitor where an image is generated by the graphic recorder.

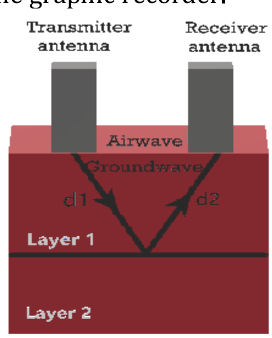

Fig. 2 Ground Penetrating radar

1)The velocity of electromagnetic wave is given by

$$v = \frac{c}{\sqrt{\in_r \mu_r \frac{1+\sqrt{1+(\sigma/\omega\in)^2}}{2}}}$$

Where: (c) = Electromagnetic wave velocity in vacuum.

($\in_r$) = relative dielectric of material.

($\in$)= Dielectric permittivity

($\omega = 2\pi f$)= Angular Frequency

($\sigma = \omega \in$)= Loss factor

(μ_r)= Low Loss Material

2) The velocity of electromagnetic waves is reduced to:

$$v = \frac{c}{\sqrt{\in_r}}$$

Where: (c) = Electromagnetic wave velocity in vacuum.

($\in_r$) = relative dielectric of material.

The image displayed on the monitor after receiving the radar signal using graphic recorder, gives the wiggle diagram which needs to be de-convoluted for many process for clear image. The diagrammatic characteristics and signal identification are recorded in the monitor using a software called "RADAN" as a reference for future studies.

C. Combination of GPR with CMP

The wiggle diagram obtained from the GPR method locates the existence of the ground water level however, many unwanted, disturbing signals still exist. The CMP(Common Mid Point) is a concept generally originated from the seismic test that not only monitors the reflectively, but also distinguishes the signal from noise for clarity image. The basic methodology is to obtain a series of signals which reflect back from the common mid-point. The signals are then summarized so that superior signal-to-noise ratio to that of single-fold stack results. The fold of the stack is calculated by the number of signal gathered from CMP.

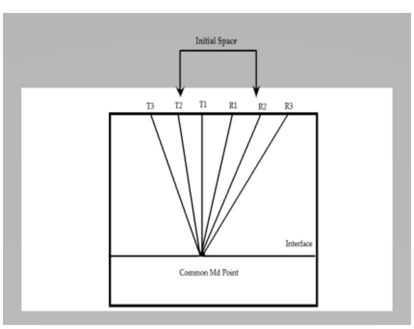

Fig. 3 Common Mid Point

There are four gathering types namely a)common short gather; b)common midpoint gather c)common receiver gather; d)common offset gather. Among these, the GPR image is improved by using common midpoint gather.

Using this method the depth received from the GPR is converted which regulates and filters the image further improving the creditability of the diagram.

D. Salinity investigation technique using VES approach

The location detected of water level is sent from the monitor to the bot that surveys the land further for salinity level using VES method. VES is a geophysical method using DC resistivity surveys that involves one-dimensional(1-D). The method involves current being applied through electrodes (A,B) which are pushed into the ground that has been detected earlier.

The depth of the penetrated rod is directly proportional to the gap between the rods. Hence, to reach the depth of the location and also details about aquifer stratification in a natural soil profile, the seperation between the rods is increased stepwise keeping the CMP of the electrode fixed.

The selection of electrodes is controlled by the type of resistivity, field conditions and sensitivity of the resistive meter. The most common configurations used are pole-dipole, dipole-dipole, Wernner and Schlumberger.

For most investigations, Schlumberger electrode is used as being less laborious. The bots are programmed in such methods that the space between the rods is increased autonomously until it reaches the located spot.

As the electrode spacing were gradually increasing, the measured potential became weak. In order to obtain the apparent resistivity as the function of depth, the measurements for each position are performed with several different distances between current electrodes. The aquifer resistivity is calculated as

$$p_k = k\frac{U_{MN}}{I_{AB}}$$

Where: (U_{MN}) = Voltage between rods M and N.

(I_{AB})= Current between rods A and B

(k)= Geometric Factor.

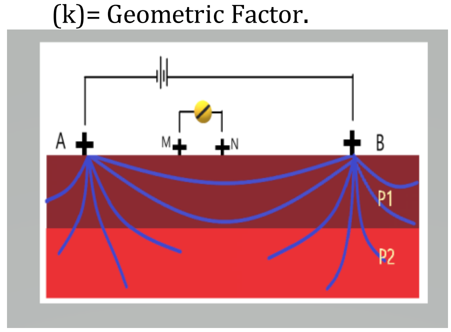

Fig.4 Vertical Electrical Sounding

When trying to scrutinize how resistivity changes in accordance with depth, multiple measurements are taken that each gives a different depth sensitivity. Hence, The measurement was repeated after each step of the electrode separation to improve data quality.

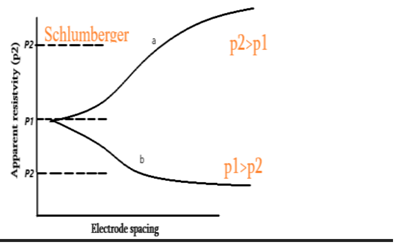

Fig 5 VES Graph

The vital factor influencing the resistivity in the investigated land is concentration of dissolved salts in the groundwater. Therefore the Electrical Conductivity(EC) of the water beneath the earth can be derived from the aquifer(VES) resistivity obtained previously. A categorization of salinity level in groundwater, called as FFI water table was developed by Sikandar in 2009, specifically for irrigation which is shown in Table I. Comparing the values obtained with the FFI table, we can come to a conclusion whether the surveyed site has feasible and fit water for irrigation.

Aquifer resistivity (VES) (Ω m)	**Groundwater electrical conductivity (EC) (dS m^{-1})pp**	**Fitness for irrigation (FFI) classification (Description) (Classes)**
>45	**<1.5**	**Fit 1**
25-45	**1.5-2.3**	**Marginally 2**
<25	**>2.3**	**Unfit 3**

Table I. Irrigation water fitness classification (FFI) based on groundwater salinities (EC) derived from aquifer resistivity measured by VES

IV. CONCLUSION

Underground water has proven to be the most efficient and easily available source of irrigation. The bots that implements the methods communicate with each other by passing required data, gives a clarity location of the presence of feasible water for irrigation amidst the other points in the field. This reduces the protracted manual searching of irrigation fit water beneath the surface.

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