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Miscellaneous Techniques of Detecting Groundwater

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***Abstract*- A significant amount of water for daily use is extracted from ground known as groundwater. Choosing right techniques for detecting groundwater is very important, especially in those area where surface water is not much available. This paper summaries miscellaneous technique of detecting groundwater.**

Index Terms— Confined aquifer, groundwater, unconfined aquifer, remote sensing.

I. INTRODUCTION

Water is the most important element in earth for all life. From plant to animal, actually for all creation in earth need water for their existence. Especially for human being it is the most important thing for survival. Water can be found either in the earth surface or under the earth which is basically called groundwater [1]. Most of the surface water is salty, that's why it is a crying need to extract ground water. Generally ground water pass down through the aquifer and confined by rocks. Groundwater accounts for 26% of global fresh water resources [2]. Oceans contains 97% of the global water resources which have only 2.8% fresh water. Fresh surface water is 2.2% out of the 2.8% and 0.6% is groundwater. So, people need the renewable fresh water for daily survival. And it is important to detect and monitor the renewable groundwater where the surface water is not available.

II. TYPES OF GROUNDWATER

Before discussing the methods for finding groundwater it is necessary to know the types of groundwater. A groundwater potential zone is called an aquifer. Based on aquifer there are two types of groundwater: one is unconfined aquifer and other is confined aquifer [3].

A. Unconfined Ground water

If the groundwater is direct contacted with the atmosphere through the open pore spaces of the overlaying soil or rock, the aquifer is called unconfined. The top of the surface of groundwater is called water table. Some factors affect the depth of the water table like topology, geology, season and tidal effects, amount of water being pumped from that aquifer. This aquifer is called renewable because it is recharged by rain or stream water.

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B. Confined Groundwater

Confined aquifer is permeable rock units which are deeper than unconfined aquifer under the ground. The surface of the confined aquifer is called head. The movement of the water is limit by overlain impermeable rocks or clay. Water in such type of aquifer is remain under pressure and it can be rised up inside a borehole drilled in that aquifer. The level of the rising water is called the potentiometric surface. It is also rechargeable by rain or stream water.

III. TECHNIQUES OF GROUNDWATER DETECTION

As surface water is not available in everywhere in earth, it is necessary to explore groundwater. But it is not an easy task to find groundwater. This task is mainly controlled by the hydrologist or an engineer. There are mainly two categories of techniques to find the groundwater. They are: (a) Surface Methods and (b) Sub-surface methods.

A. Surface Methods

This techniques is relatively easy to operate, implement and inexpensive than sub-surface methods. The minimum requirement for this are topo-sheets, maps, reports, filed measurements etc. By interpreting the data getting from those a decision is made to locate groundwater potential zones. Some of the surface method are:

(1) Esoteric Techniques
(2) Geomorphologic Techniques
(3) Geological and Structural Techniques
(4) Soil and Micro-Biological Techniques
(5) Surface Geophysical Techniques
(6) Remote Sensing Techniques

1) Esoteric Techniques:

Esoteric techniques are used by the ancient people to find groundwater. It is called water-dowsing. This techniques involve in choosing a forked or Y-shaped twig of tree or metal rods. The twig or rods are positioning between the fingers so that the felt sensation can be amplified and the rods or twig twitch and go down near the expected place. Finally crisscrossing the land to determine the most possible areas. The diving rods can be many types like Y-shaped twig, metal rods, parallel rods, the hart-mann lobe etc. The people holding the rods called dowser. When a significant water is found, the rods get crisscrossed. But this technique cannot find deep aquifer or small amount of water.

2) Geomorphologic Techniques:

Surface drainage is controlled by the basement rocks which is the subdued replica of topography. The flow of groundwater coincides with the surface drainages. These underling structures may control the streams and water courses. Junction of streams are potential zones for groundwater. Several geological processes are the reasons for creating landforms which are the indicators to show the permeable strata. Some good potential zones of groundwater are the locations of modern alluvial terraces and floodplains, stratified valley-fill deposits, glacial outwash plains, glacial deltas, kames, moraine complexes, eskers alluvial fans and beach ridges etc [4]. Physiographic methods analyze the surface topography and drainages by which groundwater potential zones can be found.

Hydraulic gradients of groundwater systems follow the topography gradients and slops which are also suitable for water storage for recharge. The ratio between the total length of all streams and the area of watershed is called the drainage density. The resultant drainage density is the indicator of potentiality of groundwater. The low drainage density indicate the higher potentiality and the high drainage density show the low potentiality of groundwater due to more streams.

3) Geological Techniques:

This techniques involve in collecting, analyzing and hydrogeological interpreting of topographic maps, aerial photographs, geologic maps etc [4]. Geologic reconnaissance and hydrologic data are also needed for this. Joints, faults and lineaments may control the drainages. This type of area may contain a good amount of groundwater.

4) Soil and Micro-Biological Techniques:

The elements in soil which is called geo-botanical indicators are the sign of groundwater in an area. Xerophytes subsisting on minimal water indicates the depth of water table. Halophytes indicates the presence of saline water. Deep rooted tree, growth of vegetation also reflects the presence of groundwater in an area. Groundwater can be found by analyzing the moist depressions, marshy environments and salt precipitations. All these geological elements are a good indicator tools for detecting ground water but this techniques cannot detect the depth or size of the aquifer.

5) Geophysical Techniques [5]:

Groundwater geophysics is the way of exploring aquifer with geophysical techniques. Physical parameters like density, velocity, conductivity, and resistivity, magnetic, electromagnetic and radioactive phenomena are observed to find groundwater in geophysical techniques. It can detect the differences, anomalies of physical properties within the earth's crust. By this groundwater potential zones are found. The most popular geophysical techniques are Gravity, Electrical, Seismic and Magnetic techniques.

Gravity Technique: In sedimentary terrain, hydrologist use the gravity technique to find groundwater and mineral resources. Gravimeters are used in this purpose which can measure the differences in density on the earth's surface that may indicate geological structures under the earth. This techniques is expensive and the differences of the gravity in content in subsurface strata and the gravity at surface has a measurable differences. For that this technique is not widely use in groundwater detection.

Electrical Resistivity Technique: The mineral and fluid content under earth and the degree of water saturation in rock have different resistivity. By measuring the subsurface resistivity it is possible to locate groundwater. This resistivity is related to the geological parameters. This is done by injecting current by two current electrodes and measuring the resulting voltage differences at two potential electrodes [6]. Wenner, Schlumberger, Pole-Pole, Pole-Dipole, Dipole-Dipole are some mostly used electrodes in this matter. An apparent resistivity is need to measure in this regards. Some techniques of measuring resistivity are following:

Vertical electrical sounding is the resistivity variation with depth. The profiling technique is the way where the spacing between the electrodes remain fixed but the entire array is moved along a straight line [7]. The wenner array is a robust array which is sensitive to vertical changes. The geometric factor of wenner array is smaller than other arrays. Schlumber array is used for Vertical Electrical Sounding (VES) by which data acquisition is done [8]. Four collinear electrodes are used in this technique in which the outer two are source electrodes and inner two are receivers. In Dipole-Dipole array the source electrodes distance and the receiver electrodes distance are same in this technique. It is very sensitive to horizontal changes but insensitive to vertical changes which is a good indicator for mapping vertical structures like dykes and cavities.

Electromagnetic Technique: Electromagnetic technique is the creation of magnetism by current flow. A solenoid is used to create the magnetic field. The strength of the magnetic field is directly proportional to the current flows. Active electromagnetic technique and passive electromagnetic technique are to types of electromagnetic technique for finding the potential zones for groundwater.

6) Remote Sensing Techniques:

Remote sensing does not need direct contact with the earth while all other techniques need direct contact with the ground. Images taken from remote satellite is the main resource for collecting information in this regards. After taking images, groundwater potential zones are found by image processing and data analysis [9]. Every part of the ground reflects the incident light and different particle reflects different amount of reflected energy in form of wavelength of the e-m spectrum. The data that identifies different object called signatures. After getting spectral signatures from the airborne and spaceborne platforms some processing are made to detect different objects. Data are collected from different satellite such as Viz-LANDSAT, SPOT, IRS-IB, IRS-1C, IR-1D, NOAA, LISS-IV, InSAR etc. These satellite provides multi-spectral, multi-temporal and multi-sensor data of ground by which mineral explorations, water resources evaluation, environmental monitoring, groundwater targeting are found through remote sensing processing [10].

B. Sub-Surface Methods

Sub-surface technique is very expensive which is generally done for government level projects for large scale investigations. It consists of "Test drilling" and "Borehole Geographical Logging Technique" which can not only find the ground water but also measure the formation properties.

1) Test Drilling:

Test drilling is the way to find the hydrological characteristics of water potential zones like rock types, fractures zones, rock fabrics etc. For this technique, a well is drilled to find the water and the geological characteristics of that potential zones. These wells are normally drilled using air-percussion rotary methods, cable-tool methods etc. Air-Percussion rotary technique uses a down hole air hammer to drill the well. Depth, drilling rate, size of cutting, changes in lithology, color of the drilling fluid are observing during the air-percussion rotary technique.

2) Geophysical Logging:

Geophysical logging technique is the way to collecting data about geological formation penetrated by a well and create a log of the data. Utilizing the natural source and stimulated controlled source are two techniques of logging records. Detection of bed boundaries, porous & permeable zones, water well design & construction etc are extracted by this technique. Some well-known logging techniques are electrical logging, radioactive logging, Induction logging, Sonic logging, Fluid logging, Caliper logging etc.

IV. CONCLUSION

The existence of life on earth is based on water. Without water it civilization cannot be thought. But it is not properly distributed all over the surface. That's why it is needed to extract water from ground for daily work. Though there are many techniques are mentioned in this paper, not all is efficient and cost effective in all area. So, it is an important matter to choose the right technique. Firstly, the right surface method should be chosen for detecting the potential zones, then sub-surface technique could be applied for water.

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Fatima Jahan Sarmin studied B.Sc. Engineering in Computer Science and Engineering from Rajshahi University of Engineering and Technology. Currently she is doing M.Sc. in the same university. She is working with groundwater detection techniques. She has research interest in GIS, remote sensing in groundwater detection etc.

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