HYDROLOGICAL INVESTIGATIONS

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INTRODUCTION

Since independence there is considerable advancement in the field of hydrology, specially in the design of dams, water resources development and planning, hydrological Investigations and research. Every subject on hydrology as mentioned above needs the information/data on various components of hydrological cycle such as rainfall, evaporation, wind, temperature, humidity, soil moisture, surface runoff, ground water runoff, ground water recharge,etc.,. Hydrological investigations are required to be conducted to find out information in each of these items. Information on these components excepting for rainfall was almost negligible prior to independence. The data of these components are now being observed throughout India by different organizations. Advancement in observation of various components of hydrological cycle and organizations which are responsible for its observation and maintenance have been discussed in this Chapter.

Measurement of Hydrometeorological Components of the - Hydrological Cycle:

Rainfall, evaporation, wind, temperature, humidity, sun shine hours and cloud cover form the hydrometeorological components in general.

For the measurement of weather parameters/ hydrometeorological parameters, the India Meteorological Department under Ministry of Science & Technology is solely responsible. This department also manufactures different instruments used for the measurement of the weather parameters. However, Water Resources Departments, Irrigation Departments and Agricultural Departments of different states maintain raingauges or observatories at desired locations such as dam sites, agricultural farms, research institutes, laboratories, etc., .

Rainfall

Rainfall is being observed in the country since very long time. We have the records of rainfall observed at various places right from 1901. However, most of the records have been made using non recording type instrument, i.e. they are measured by manual labour. Presently, continuous record of rainfall is being observed by the use of self recording raingauges. The recording and non-recording raingauges are being manufactured by the IMD, some other Central Govt. Organization like ordinance factories, and also by various private agencies like Dun Engineering Company, Lawrance and Mayo, etc., .

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Evaporation

The process by which the precipitation reaching the earth's surface is returned to the atmosphere as vapour. Evaporation is one of the important phases of hydrological cycle and stands next to precipitation and surface runoff in the context of hydrological studies and water resources management aspects. Of course a scientist in water science is of ten concerned with total water losses into atmosphere which include evaporation from water surfaces, soil and vegetation and also transpiration by plants. These total water losses into atmosphere are known as evapotranspiration losses. However, the process of evaporation is of prime importance to a hydrologist.

Evaporation is mainly effected by (a) difference in vapour pressures of liquid and air; (b) temperature; (c) wind; (d) atmospheric pressure, (e) quality of water; (f) nature of evaporating surfaces such as soil surfaces, water surfaces,vegetation, snow and ice.

Techniques of measurement of evaporation are known since long and the actual measurements started quite long back in countries like America, United Kingdom and USSR. But the measurement of evaporation losses started on firm footing in India only after independence.

Instruments for measuring the rate of evaporation are called atmometers, evaporimeters. evaporimeters or atmidometers. Atmometers are most generally used which can be segregated into three classes viz. a) tanks or pans, b) porous porcelain bodies & c) wet paper surfaces. Evaporation tanks or pans, commonly used for ordinary measurements, are made of galvanized iron, zinc or copper, are usually circular, and are made in various sizes.

They may be painted or unpainted and their tops may or may not be screened. They may be installed above or in the ground or may float on a water surface. Out of various types of evaporimeters, class A evaporation Pans developed and standardized by U.S. Weather Bureau are popularly used in India for measurement of evaporation of water surface. However the measurement made in this way is not exactly same as natural evaporation from water surface. So, a coefficient of 0.6 to 0.8 is used as a multiplier to obtain the actual evaporation data from the observed pan evaporation data. Attempts have been made to observe the evaporation on actual water surface, in a reservoir or lake. At some reservoirs, for example at the Peechi Dam in Kerala, The measurement of evaporation from the reservoir surface was attempted by arranging a class A evaporation Pan on a big bambooraft.

Daily evaporation information is equally important for a farmer who irrigates his land for growing crops. But a farmer can not afford to have a big evaporimeters like Class A Pan which is of 4 ft in diameter. For the purposes of approximate and cheap measurement on an agricultural farm, a portable evaporimeters is used. These are not very popular in India, but in some areas in Kerala & Tamil Nadu around Coimbatore, these portable evaporimeters were used under the C.G.W.B.-SIDA (Swedish Internation Development Authority) assisted Groundwater Project during 1975-1980. In the same project area automatic recording evaporimeters have also been used to have continuous record of evaporation from which rate of evaporation as a function of temperature, wind speed,humidity or a combination of two or more of above parameters can be estimated. However, use of these recording evaporimeters is on very small scale in India.

It is generally known that evaporation rates are very high and consequent losses are of high magnitude. The effect of evaporation of the water surface of big reservoirs is quite considerable. So some methodologies have been developed to reduce the evaporation from water bodies which include.

(a) Formation of monolayers using polar molecules consisting of a hydrophonic (water repelling) and a hydrophillic (water attracting) parts;

(b) formation of multimolecular layers of oil mixture

(c) films of 5 microns thickness consisting of paraffin oil containing spreaders of high molecular weight,

(d) duplex films of 1 to 100 microns thick

During the dry year of 1985-86, in the Aji, Bhadar and Nyari reservoirs of Gujarat, attempts have been made to reduce the evaporation by use of chemical powder to form a thin film to arrest evaporation and achieved a saving of about 15 to 20%.

The CIFT (Central Institute of Fisheries Technology) developed an evaporation sensor for remote operation. The sensor can be connected to the meter in the laboratory for the display. It is removes the manual observation there by avoiding the manpower deployment and human error possibility. The range of the measurement is 40 mm with an accuracy of 0.1 mm.

Wind

Both direction and speed of the wind are required to be measured. For measuring direction of wind, wind vanes are employed. For measurement of wind speed, anemometers are employed wherein a cup type arrangement is made to rotate in a horizontal plane when placed in the open air due to wind movement. The number of revolution of the anemometer are measured and directly calibrated to the wind speed. This is a continuous recording system.

Temperature

Measurement of temperature is being made in the country since long time. For measurement of the temperature, thermometer is used in general. As the temperature varies during the day and night, due to diurnal variation, a maximum and minimum thermometer is used to record maximum and minimum temperatures of a day. These thermometers are being manufactured by various governmental and private agencies. This is a non-recording system. However, we have continuous measurement of temperature by using an automatic thermograph which makes continuous temperature recording on a chart rolled around a drum of the thermograph.

In order to facilitate continuous measurement of multiple components such as temperature, humidity and atmospheric pressure, we have automatic thermo-baro-hygro graphs. These have been employed in the pilot research projects taken up by the Central Ground Water board.

The CIFT developed instruments to measure the temperature remotely from the plant canopy, soil depth or water depth provided with small and tiny sensors and long cable of several hundred meters of ordinary type in order to make continuous automatic measurement of the soil temperature, air temperature or water temperature. These meters provide digital display and paper charts. The range of temperature that can be measured by these instruments is from -60 C to +150 C with an accuracy of 0.1 C.

Relative Humidity

Humidity is the measure of amount of moisture in the atmosphere. To measure the humidity, the wet and dry bulb thermometers are employed. As mentioned above automatic continuous recording of humidity is also obtained by using automatic hygrograph. The thermo-baro-hygrograph records continuously the relative humidity alongwith other components, temperature and pressure. The CIFT developed a remotely operated relative humidity measuring device with the features that the remote operated sensors can be kept far away inside plant canopy, inaccessible points, warehouses, etc., with the temperature range of -10 C to +60 C and with an accuracy of 0.1 and these can be permanently installed at remote sites and continuous measurements can be made.

Sun-Shine Hours

Sun-Shine hours is the measurement of bright sunshine available during day period. This is being measured continuously with the help of a spherical lense. The sun's rays after falling on this sphere, focus on to a chart which is cut continuously due to absorbed heat. Three types of charts are used during the year depending upon the earth's orientation which varies seasonally. These are generally installed in the class A observatories of the IMD. However, these have been installed in the pilot research projects taken up by in the CGWB in collaboration with the foreign agencies as mentioned above.

Measurement of Surface Water Component of the Hydrological Cycle

Observation of gauge and discharge at various locations of river and on different rivers in different river basins is being done to obtain the information on surface water resources of the country. The Central Water Commission is solely responsible for these measurements on all india basis. While State Water Resources Departments/ Irrigation departments are responsible for their measurements of these components for the river systems falling in the respective state's jurisdictions.

River Stage

River stage is the measurement of water level of the river at any location with reference to the mean sea level. In general, the river stage is being measured by connecting the stream water level with the nearest G.T.S. bench mark. For this purpose staff gauges are used. The zero reduced level of the gauge is fixed by connecting it with the nearest G.T.S. bench mark. Then the stream water level is observed in terms of gauge height. Knowing the gauge height and the zero RL of the gauge,the stream stage is evaluated. This is a non-recording system.A development in the field of measurement of river stage is the introduction of automatic water level recorders. These recorders are installed near the required section of the stream by making a stilling well. A stylus makes continuous record of stream stage fluctuation on a chart which is fixed to a rotating drum of the AWLR. This is a self recording system. There is another device called pressure gauge. A diaphram is used to translate the pressure of the water column above it and is directly calibrated to stream stage. But this arrangement is not popular in India whereas use of AWLR is quite popular in most of the departments.

The CIFT developed water level measuring instrument with the following features.

Remote operated sensor alone need to be kept at the site connected to its meter by long cable; no gauge well needed and hence installation is easy and inexpensive. Several small type sensors installed in a complex water distribution system can be attached to a single meter, for simultaneous measurements and analysis.

Discharge

The measurement of discharge in stream is usually done by observing the average velocity of the stream using a convenient method and multiplying it by the cross sectional area.

In the earlier times, the velocity of the stream used to be measured by using a float, such as a grass ball or a light wooden piece or a floating leaf. Now, the average velocity of the stream is being measured using a current meter. Current meters are of two types, viz. cup-type current meter and propeller type current meter. In India cup type current meter is widely used whereas propeller type current meters are used by very few organizations. The cup type current meter contains an arrangement of cups which rotates horizontally when placed in a stream at any desired location where there is current. The number of revolutions is measured during a particular time period. This number is directly calibrated to the velocity of the stream at the point of observation. The cup-type current meters are being manufactured in India by various Governmental organizations such as ordinance factories and few private agencies like Doon Engineering Company, Lawrance and Mayo, etc.,.

When a propeller type current meter is placed in the stream at the desired location keeping the propeller against the current, the number of revolutions of the propeller during a particular period of time are recorded. This number is directly calibrated to the velocity of the stream at that location. Propeller type current meter used to measure, the low velocity is called pigmy current meter. These are generally being imported from Germany.

All these current meters face the problem of drifting in high velocity streams. Another associated problem is the time taken to fix the current meter at a desired location and at desired depth which takes longer time to complete observation at a cross-section. Observation at one cross section of the stream in case of big rivers with high velocities, such as Ganga in monsoon season takes nothing less than 6 to 7 hours. To overcome these difficulties a method called 'Moving boat method' has been invented and is being put to use in India on major rivers where high velocities and long cross sectional width of the stream exist Central Water Commission maintains a moving boat at Patna to observe the discharge of Ganga. The advantage of moving boat is that it continuously records the number of revolutions of the current meter while moving across the river. It completes the coverage of the river section in full flood state within a short period of about 20 to 30 minutes.

Measurement of stream discharge in upper reaches some times causes a problem due to narrow gorge and high banks. In this case, a cable way is being used to position the current meter at a desired location on the stream. Central Water Commission has such arrangement at quite a number of places, for example in the upper reaches of river Ganga near Dehradun in U.P.

The CIFT developed sensors and measuring techniques having unique features and following advantages.

The rotor produces pulses without any mechanical or magnetic load and hence offers minimum wear and tear; inexpensive and easily replaceable rotor avoids the need for occasional calibration; sensors can be kept far away connected by 2-core cable, which provide better facilities and the sensors can be installed permanently in the canals or rivers using suitable mounting supportsand data displayed or recorded in the range 0 to 500 cms/sec.

MEASUREMENT OF SOIL MOISTURE COMPONENT OF THE HYDROLOGICAL CYCLE:

The tem "soil" refers to the weathered and fragrant outer layer of the earth's land surface. It is found in varying thickness at various places. It is formed initially from the disintegration and decomposition of rocks by physical and chemical processes. Soil is a heterogeneous and porous system. Water and air generally fill the pores available in soil mantle. The water available in the soil help growth of plants. As such a study of the moisture available in the soil mantle is essential to understand the available water in the soil at different levels below ground surface and upto ground water table and in different soils.

Obtaining reliable measurements of soil moisture is one of the most difficult problem in hydrology. Not only are there considerable difficulties in determining the water content of the soil at a particular point, but also the special variability of soil properties makes it difficult to obtain reliable measurement.

Though the importance of moisture in the soil zone is known since long time, no effort has been made, until recently to monitor and quantify the soil moisture. During last two decades, some attempts have been made to measure the soil moisture. There are broadly two methods viz. direct and indirect methods, of measuring soil moisture. In the direct method, soil samples are taken from field and then analyse in a laboratory. This method involves the inaccuracies due to disturbances in obtaining the field samples. Lysimeter are also used for the determination of soil moisture as a direct method. The indirect method does not require extraction of soil samples from the field instead, moisture is measured in - citu. In this case accuracy of the results is better when compared to that of direct methods. Under the direct methods soil sampling and drying (gravimetric) is the most common technique. Electrical resistance blocks, neutron - probes,tensiometers are some of the techniques employed under indirect methods. The most recent advancement indicates the use of gamma ray attentuation, use of ultrasonic waves, microwave moisture meters, hydrophotographic method and optical transmission method. However, these new techniques are not routinely used as compared to the other conventional methods.

In the direct method techniques, the soil samples are obtained in the field by using a hand auger or some other soil extraction sampler. These samples are taken to laboratory where the weights of the soil samples are determined. After drying out the sample again the weight is obtained and the difference between the two is taken as the moisture content available in the soil. Under the indirect methods, use of electrical properties or radio active properties are employed and analysed to obtain the soil moisture.

The lysimeters are employed to obtain soil moisture measurement in India at few of the research laboratories and research organizations. The NIH has one lysimeter.

The most recent development techniques are Captical Transmission Method,Microwave Transmission Method and Time Domain Reflectometry system. These methods are described below:

Optical Transmission Method

The method of optical transmission is based on the fact that light transmission of quartz sand increases with the water content in narrow samples. The increase in light intensity depends on light absorption moduli of sand,water and also on the number of pores full of water. Since, the relationship between number of pores full of water and the water content is not unequally known, calibration procedure is needed for every photo sensitive probe.

Microwave Scattering Method

Forward scattering of microwaves is a function of the soil water dielectric constant, via the reflection coefficient. The basis of this method depends on the fact that the dielectric constant of water is very high compared to that of dry soil. The dielectric constant of soil can be increased to more than 20 by adding water to dry soil. The increase translates into a change in some parameter which helps radar to sense the variation in moisture content.

Time Domain Reflectometry (TDR) System

Time Domain Reflectometry is a technique operating over a range of Radio frequencies, which can be used to measure the high frequency electrical properties of materials. In soil applications, TDR is used to measure the dielectric constant which increase with increased moisture content in the soil. The TDR method is capable of giving a precise and early determination of soil water content in fields with an accuracy of 2%. moreover, because of strong dependence of the dielectric constant on water only, there is no need to calibrate the TDR for different soils. Measurement of soil salinity and detection of frozen layers within the soil can also be done with the TDR technique.

Soil moisture is being monitored and quantified at some desired locations only by some organizations which are dealing with research aspects of soil moisture studies. The soil moisture is not being observed on a country-wide basis by any single organization.

Organizations carrying the soil moisture measurements

The soil moisture measurements are generally carried out by the following Government, Semi-Government and academic organizations.

Central Soil Salinity Research Institute,Karnal, Haryana; ICRISAT,Hyderabad; National Geophysical Research Institute,Hyderabad; Water Technology center,Delhi and Agricultural universities situated at Pantnagar,UP; Hissar, Haryana; Punjab Agricultural University, Ludhiana; Dehradun, UP; Coimbatore,TN; etc.,.

HYDROLOGICAL NETWORK DESIGN

Raingauge stations are required to monitor rainfall data and stream gauging stations are required to monitor stage and discharge measurement of the stream. The establishment of these stations involve in considerable expenditure which depend upon the financial resources of the organization which is responsible for monitoring these data. A sparse net work may not be sufficient to obtain reliable information or it may involve in higher percentage of error. On the other hand to have increased accuracy, we need a dense network of these stations. The high density network needs lot of financial resources and manpower. As such an optimal number of stations are required with a tolerable percentage of error in obtaining the data with reasonable input of financial and manpower resources As mentioned earlier the stream gauging stations and raingauging stations were small in number which made us not to have sufficient and reliable data. However, after independence, with increasing awareness for the hydrological data and its importance establishment of the raingauge and streamgauge stations.These stations can not be established to have higher densities as mentioned above due to restrains on financial resources and man power availability as well as no considerable increase in the accuracy beyond certain density. Under these circumstances it is required to establish the stations to give reliable data within tolerable error limits and with minimum expenditure of financial resources and deployment of manpower. The technique of establishing optimum number of stations is known as hydrological network design. Two basic scientific problems in network design are (a) to determine how many data acquisition points are required and (b) where to locate them.

The world meteorological organization (WMO) has prescribed some norms for establishing these stations as a function of area covered by each station and the type of area in which the station is going to be located. In general,these norms are followed in case very few stations are to be established.However, in a particular basin, either because of its situational importance such as international rivers wherein international water disputes may arise or its importance in view of the low availability of the water resources and high demands for water. Reliable data is to be obtained for such situation. More number of stations are required to be established. In such cases, the hydrological network design comes into the picture. The organizations like Central Water Commission, State Water ResourcesIrrigation Departments and few research organizations are involved in the design of network of raingauge stations stream gauging stations. As per Langbein, a network is an organized system for the collection of information of a specific kind. Hydrological and hydrometeorological data are required mainly to provide information for developing and managing the water resources. They are also used for operating and forecasting purposes. The design of hydrological and hydrometeorological station network involves in obtaining data at few representative locations on permanent basis and on temporary basis at other locations with a view to develop relationship between a temporary station and a permanent station. After obtaining a reliable relation between a permanent station and temporary station, the data observation at temporary station is discontinued. The permanent stations are called base stations and temporary stations are called secondary stations. These secondary stations are discontinued after monitoring the data for a considerable period and obtaining a reliable relation between a base station and a secondary station. Then another secondary station at a different location will be established. By this way of rowing, larger area will be monitored with less number of stations and less manpower, at the same time within the tolerable error limits.

Guide lines for design of the hydrological network station

WMO Guidelines

For raingauge station network the following table gives range of area covered by each raingauge station in different regions as per the World meteorological organization

WMO Guidelines for Streamgauge Station Network

Following table gives range of area covered by each stream gauging station in different regions .

As mentioed above, in general, the above guide lines prescribed by the WMO are being followed in most of the cases in our country.

Table - 1 Minimum Density of Hydrometric Network

Type of region		Range of norms for minimum network Area(Sq.km) per station	Range of provisional norms tolerated in different conditions area(sq.km) per station
(a)	Flat regions of temperate, mediterrancan tropical zone	1,000-2,500	3,000-10,000
(b)	i) Mountainous regions of temperate, mediterranean and tropical zones	300-1,000	1,000-5,000
	ii) Small mountainous islands with very irregular precipitations, very dense stream network	140-300	
	(c) Arid and polar zones	5,000-10,000	

1. Last figure of the range should be tolerated only for exceptionally difficult conditions.

2. Great deserts are not included.

3. Depending on feasibility.

4. Under very difficult conditions this may be extended to 10,000(Sq.Km.).

Table - 2 Minimum Density of Stream Gauging Station Network

Type of region			Range of norms for minimum network Area (Sq.Km.) per station
(a)	Flat regions of temperate, Mediterrancan and tropical zones.		3,000-5,000
(b)	i)	Mountainous regions of temperate, mediterranean and tropical zones	1,000
	ii)	Small mountainous islands with very irregular precipitations, very dense stream network	
(c)	Arid and polar zones		10,000

Empirical Formulae

Following are different empirical formulae:

Formula suggested by Benson based on multiple regression techniques. This formula has been used in some of the studies conducted in the National Institute of Hydrology, Roorkee.

$$N = 22.9\ A^{.26}\ P^{.22}\ R^{.21}\ W^{.11}\ I^{.5} \quad \text{(standard error 28.5\%)}$$

where

N = total number of gauging stations in a particular area,
A = area in thousand sq.miles,
P = population in millions in the year under consideration
R = relief in thousand feet,
W = surface water use in acre feet,
I = irrigated area in thousand acres

(ii) Empirical equation suggested by Langbein. This is also being used in many cases in our country.

$$N = T/(1 + ((Ne/(Nr-2))(0.4\ K^2A/B)))$$

where

N	=	effective length of an extended record
Ne	=	period of extension
Nr	=	Length of available record
T	=	total period = Nr + Ne
K	=	increase in the standarderror per kilometer distance between the catchments of drainage under consideration for correlation(assumed as 0.01)
B	=	Number of base stations
A	=	Total area of the catchment

For a short period of available record, there should be a maximum period of extension. Maximizing N-Nr, Ne is determined which is the period for which a secondary station is to be operated. Assuming the number of base stations and secondary stations, total period(T), the number of gauging stations in a given period, T, total number of gauging stations to be operated over a total period of T, is equal to

$$NBS + NSS * (T/Ne)$$

where

NBS	=	number of base stations
NSS	=	number of secondary stations,
T	=	total period in years,
Ne	=	period of extension.

During recent years, most approaches to network design have seemed to fall into one of several broad categories, the regionalation and systems analysis approaches.

Regiónalisation

Regionalisation deals with the distributed rather than the point values and with treated data rather than in their original form. Regionalisation can be employed to plan a stratified sampling scheme,so that the range and interactions of the important parameters are adequately sampled, and each point of data collection samples a unique combination of factors of the terrain. Even with the ideal distribution of data acquisition points, however, there is likely to be a residual standard error, which accounts for all the other discrepancies in the network. When a network is operated on a fixed budget, then a minimum error of prediction of the hydrological variables should be the aim, if a given level of accuracy is required, then the objective should be a minimum cost net work.

System Analysis

System analysis approach for network design is based on the optimization of some goal, subject ot constraints imposed upon the system. Constraints may be economic, manpower, etc.,. For each objective, the effect of various numbers and configurations of data inputs can be examined by systems analysis, and this has made possible the development of a fresh approach to network design.

In order to design a network within a systems analysis framework, the information content of the data must be translated into economic worth.Improved networks should lead to better under standing and prediction and also to financial savings, system analysis can help to answer the problem of;

(i) where should resources be invested in a network

(ii) should the network be expanded or curtailed

(iii) should thes instrumentation to be altered,and

(iv) should greater use be made of the existing information.

Automatic Data Acquisition Station

Most recent development is to monitor data continuously and record in a nearby station.This is called automatic data acquisition station. One such system has been acquired by the National Institute of Hydrology, Roorkee, namely, the Teledat 2000 Data Acquisition Station to monitor continuously lysimetrical and meteorological data and record the values at a specified periodicity. It can also be used to monitor continuously the water level of any stream. The teledat 2000 Data Acquisition Station contains following sets of sensors.

1. Typical Meteorological sensors
2. Typical lysimetric sensors
3. Other sensors.

(a) Typical Meteorological Sensors

There are following eight meteorological sensors under the above set;

(i) Air Temperature
(ii) Humidity
(iii) Wind Direction
(iv) Wind speed
(v) Global radiation
(vi) Sunshine duration
(vii) Air pressure
(viii) Rain

(b) Typical lysimetrical sensors

There are following five lysimetrical sensors under the above set.

(i) Balance radiation
(ii) Ground temperature
(iii) Conductivity
(iv) Weight
(v) Water flow

(c) Other Sensors

Under this set, there are two sensors viz. (i) water level and (ii) TELEDAT Battery Voltage Superision.

Each sensor is meant to monitor a specified data continuously. Each meteorological sensor is connected to the appropriate interface and these faces are periodically interrogated by the C.P.U. to record sensor data. Periodicity of the acquisition is a function of the kind of data as indicated below.

30 Minutes for physical parameters with slow evolution speed like temperature, humidity, air pressure.

4 Seconds for physical parameters with fast evolution speed like wind ,rain, sunshine.

Periodically, the values given by the sensors are Processed by the CPU and formulated into an ASCIE message indexed by the TIME. The time interval to produce such message in relation with acquisition cycles, and generally, the message is generated when a complete sensor acquisition cycle has been executed. Generally this interval is fixed to 30 minutes. This message stored in the station memory, is sent to the printer and recorded in the tape if the tape recorder is ready. Generally 300 messages are recorded on one side of the tape (Casettee). A maximum of 20 messages can be stored in the Teledat memory if the tape recorder is not ready due to power failure,i.eit can store data for about 10 hours. When the tape is available,all the stored messages are recorded on the tape.

GEOPHYSICAL INVESTIGATIONS FOR HYDROLOGICAL STUDIES

The science of geophysics deals with the physical properties of earth.Ground water is a resource located below ground surface. The science of geophysics offlate,specially after independence, is being used for ground water exploration.

The parameters such as gravitational property, magnetic property, electrical property and seismic property of the earth are generally considered in geophysical exploration. The gravitational and magnetic properties are natural field forces, while, the seismic and electrical properties can be artificially created and used . The geophysical methods are reliable, less time consuming and cheaper. It is quite desirable to takeup geophysical surveys prior to any drilling.Offlate, the radio active properties of earth are also being used for ground water exploration.

Geophysical surveys can be employed for obtaining information regarding distribution, thickness and depth of groundwater bearing formations, mapping of buried channels, faults and dykes, delineation of boundaries of saline waters and ground water quality.

Methods such as Gravitational, magnetic, electrical resistivity and seismic methods are employed under surface geophysical investigations.

Resistivity logging, potential logging temperature logging, caliper logging, and logging of Radioactive properties, fall under subsurface geophysical investigations.

Surface geographical Investigations:

Gravitational Method

The gravity method measures difference in density on the earth surface which may indicate geologic structure. As differences in water content in subsurface strata do not count for measurable differences in specific gravity at the surface, the method has little application to ground water prospecting.

Magnetic Method

The magnetic method enables magnetic field of the earth to be mapped. As magnetic contrasts are not clearly associated with ground water occurence, the method has little relevance.

Electrical Resistivity Method

The electrical resistivity of a rock formation limits the amount of current passing through the formation when an electrical potential is applied. It may be defined as the resistance in ohms between opposite faces of a unit cube of the matter. The resistivities of rock formation vary over a vide range depending on the material, density, porosity, pore size and pore snape, water content, water quality and temperature. Actual resistivities are determined from apparent resistivities which are computed from measurements of current and potential difference between pairs of electrodes placed in the earth surface. Resistivity meters are used for this purpose. In practice various standard electrode spacing arrangements have been adopted. The most common are the Wenner and Schlumberger arrangements Any factors which disturb the electrical field in the vicinity of the electrodes may invalidate the resistivity measurements. Buried pipe lines, cables, and wire fences are common hazards. Extremely dry conditions may necessitate moistening the ground around electrodes to establish proper earth contact.

Seismic Method

The seismic refraction method involves the creation of a small shot at the earth's surface either by the impact of a heavy instrument or by exploding a small dynamite charge and measuring the time requirement for the resulting shock or shockwave to travel known distances. Seismic waves follow the same laws of propagation as light rays and may be reflected or refracted at any interface where a velocity change occurs. Changes in seismic wave velocities are governed by changes in elastic properties of the formations. Porosity tend to decrease wave velocity and water content increases it.

Subsurface Geophysical Methods

Logging techniques within a well can provide data on properties of the formation, water quality, size of well cavity and rate of ground water movement. Evaluation of these factors aids in proper location, construction and development of wells.

Resistivity Logging

This is possible only in encased wells, within an encased well, current and potential electrodes can be lowered to measure electrical resistivities of the surrounding media and to obtain a trace of their variation with depth. The result is a resistivity log. Such a log is affected by fluid within a well, by well diameter, by the character of surrounding strata and by ground water. Of several possible methods, multi electrode method is most commonly used.

Potential Logging

The potential method measures natural electrical potentials found within the earth. Potentials are referred to also as self potentials, spontaneous potentials, or sunfly "SP". Measurements, usually in millivolts, are obtained from a recording potentiometer connected to two like electrodes,usually one electrode is lowered into well and the other connected to the ground surface.

Temperature Logging

A vertical transverse measurement of groundwater temperature in a well can be readily obtained with a recording resistance thermometer. Such data may be of value in analyzing subsurface conditions.

Caliper Logging

Well diameters can be measured along a well by means of a hole caliper.A caliper contains arms. With the arms closed, the instrument is lowered to the bottom of a well where the arms are released by detonating a small shot. The average hole diameter is then logged as a continuous graph by recording resistance changes while the caliper is run up the well. This is useful for locating carrying zones.

Radio active Well logging

Radio activity may be defined as a property exibited by certain substances from which electromagnetic radiations emanate. This property is noted in a number of elements, chiefly in the rare earths, Uranium thorium,radium and in the potassium seeds. It is a feature i.e. unaffected by heat, pressure or other extraneous effects that may be encountered in a water well borehole.It is fairly constant over thousands or even million years. During the process of electro magnetic radiation, alfa, beta, and gamma rays are given off. Measuring the radio active properties and using those properties for interpretation in ground water exploration is being increasingly adopted now a days.

These properties can be logged in a cased well only. Now-a-days we have loggers which can log most of the above parameters.These loggers are mounted on a vehicle and carried to the required places.

The geophysical investigations on larger areas for ground water prospecting are being carried out by various government agencies viz., National Geophysical Research Institute (NGRI), Central Ground Water Board (CGWB) and different State Ground Water department.

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