

# NEWER TECHNIQUES OF WATERSHED MEASUREMENTS

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## ABSTRACT

To keep pace with the advancement of hydrologic investigations and research with more and more computer applications in water resources engineering leading to formulation of a large number of watershed models specially in developed countries, the need for intensive instrumentation of watershed, longterm monitoring at shorter time intervals, automation of monitoring techniques, electronic recording, storage and retrieval of data through computer interfaces and development of reliable equipments is increasing more than ever. Long term measurements of watershed parameters with sustained accuracy is the single most factor having all round impact on the efficient management of water resources and its development of the watersheds. Therefore, water resources managers are always on the look out for better materials and methods for watershed measurements. In this chapter the authors review some of the recent advancements in equipment for watershed measurement related to hydrology and allied subjects.

## 1. INTRODUCTION

Watershed management and research need long term measurements of watershed parameters. Adequate instrumentation of watersheds with reliable equipment is an important aspect for collection of data and hydrologic research. With the increase in knowledge about hydrologic systems, there is need for improvement in the quality of data and advancement in equipment or monitoring technique. Watershed investigators in India and abroad now use a wide range of hydrometeorological equipment. Advancements in these equipment and also development of new equipment to suit the increasing requirements are taking place everyday. Many government institutions and private firms are engaged

for a long time towards these advancements. Though it is not possible to list out the activities in detail, few state-of-art advancements (some of them seen personally in the US) in the areas of hydrometeorology, water quality, geo-hydrology and soil science have been reviewed in the chapter.

## **2. HYDROMETEOROLOGICAL MEASUREMENTS**

### **2.1 Automatic Agro-Meteo Station**

For many applications the usefulness of the data increases considerably when measurements are carried out continuously over an extended period. When traditional measuring equipment is used, an observer must go out in the field at regular intervals. Particularly when short measuring intervals are required, this is quite a drawback and in practice it also causes irregularities in the measurement strings. The Agrometeo station developed by Eijkelkamp, a leading Dutch company, measures continuously with the required intervals the meteorological variables: wind speed, wind direction, global radiation, air temperature, air humidity, precipitation and soil temperature.

The usual sensors and data loggers claimed to be more satisfactory than WMO standards have been designed to remain operative under extreme climatological conditions and for long periods. The core of the meteostation is the meteologger, which ensures that the measurements are carried out in time and the registered values are recorded in the data block. The data block is a 128 KB external memory pack which can be readily exchanged without interrupting the observations. The most recently measured values can be read directly on the logger display.

The Belfort Mechanical Weather Station (Cat No. 1070 and 1080 series of Belfort Instrument Company) incorporates wind speed, wind direction, and temperature measuring into one instrument. An optional feature is the measuring of precipitation. The clearly marked and scaled chart paper lasts for 30 or 60 days of unattended use, depending upon chart speed.

### **2.2 Ultra-Sonic Snow Gage**

The Belfort Ultrasonic Gage (Cat-NO. 900) is a three piece system consisting of an environmentally sealed acoustic sensor and a microprocessor board. The system measures, processes, and outputs distances. The acoustic sensor assembly houses the reference distance rod which allows for accurate computation of the speed of sound. The processor

board times the reference distance and computes an accurate speed of sound and thus distance.

### **2.3 Hygrothermograph**

The Belfort Hygrothermograph (Cat. No. 594) is a combination temperature and relative humidity recorder. Dual sensing elements ink their traces on a single, two channel rectangular chart. The temperature pen is actuated by either a liquid filled burden tube, or a bimetallic element depending on the instruments usage. The humidity pen's moment is caused by the increase or decrease of humidity acting on a human hair element causing it to expand or contract.

### **2.4 Dew Point and Dew Point/ Temperature Sensors**

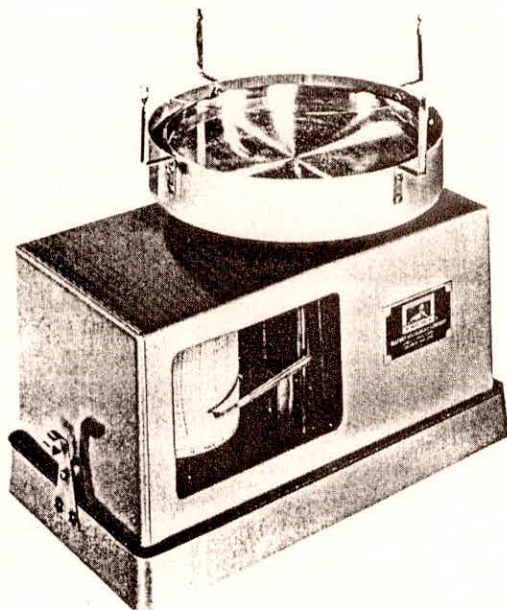
The dew point and dew point/temperature sensors provide an accurate and reliable means of obtaining air moisture and temperature measurements over a wide range of conditions. The dew point of air, or the frost point below 0°C, is defined as that temperature to which a given parcel of air must be cooled at a constant pressure and water vapour content in order for the parcel to be saturated and condensation to begin.

The dew point sensor is a lithium chloride dew cell that operates on the principle of phase hygrometry. The sensor consists of bifilar electrodes wound on a wick impregnated with lithium chloride salt. The hygroscopic salt will conduct an electrical current between the electrodes as the wick absorbs moisture from the air. A current applied to the electrodes heats the wick and evaporates the moisture to about 11 percent R. H. at its surface, where the lithium chloride becomes crystalline and conductivity ceases. The temperature required to maintain equilibrium at a constant ambient air flow is measured by thermistors inside the dew cell, and is directly proportional to the dewpoint temperature of the ambient air. The temperature sensors are comprised of dual thermistor and resistor network sheathed in stainless steel. These circuits provide a linear resistance output over an extended temperature range.

### **2.5 Evaporation Recorder**

The Belfort Evaporation Recorder (Cat. No. 6075) is an instrument for accurately recording the amount of water evaporated from a surface 250 sq cm in area. It is light weight and compact and since it requires no outside power, may be used in remote areas.

The measuring range is such that the full scale on the chart represents 0 to 20 mm of water column or 0 to 20 kilograms per meter of water evaporated. The record is made on a hand wound spring driven drum chart, rotating once in 24 hours. Since the chart drives itself and has an eight day running time, continuous recording of up to seven days call can be made on a single chart, the trace appearing as an ascending spiral.



*Fig. 1 Evaporation Recorder*

### **3. WATER QUALITY MEASUREMENTS**

#### **3.1 Spectrophotometer Analysis**

The Spectrophotometer DR/3000 developed by the Hach Company, Colorado is a state-of-the-art instrument for colorimetric testing. It combines microprocessor technology with advanced single beam optics to bring greater speed. By recalling programs stored in the DR/3000 and using specially developed Hach procedures and reagents, over 70 water quality parameters vital in industry can be measured in direct concentration units.

#### **3.2 CEL/700 Portable Laboratory**

With 10 interchangeable filter modules containing the stored calibration

for 75 tests, the DR/700 (HACH) a light weight, portable instrument that permits quick analysis of concentration of chlorine, silica, COD, nitrogen, ferrous iron, aluminum, sulfide etc.

### **3.3 HACH ONE ISE Electrodes**

Hach One Ion Selective Electrodes provide a complete analysis package for measuring ammonia, calcium, chloride, cyanide/iodide, nitrate, sodium, fluoride and potassium. The nitrate ISE employs an extremely low solubility ion exchanger to a given linearity and performance at low nitrate concentrations. Potassium ISE uses the macro cyclic antibiotic valinomycin in a solvent polymer PVC matrix membrane for superior potassium selectivity. Fluoride and Calcium ISEs offer longer life and optimum performance due to its refillable internal electrode solutions. Similarly the Ammonia ISE features a detection limit below 0.07mg/l and a linear electrode response from 0.7 to 14.00 mg/l. Chloride ISE is versatile enough to measure accurately and easily all aqueous samples including coloured and turbid samples like in water treatment.

### **3.4 Digital Titrator**

Hach's Digital Titrator is a precision dispensing device fitted with concentrated titrants in compact interchangeable cartridges. Each turn of the delivery knob dispenses a calculated amount of titrant and the end concentration is determined from the counter on the dispenser. Instead of measuring a separate burette for each titrant, digital titrator users simply change cartridges.

### **3.5 Diluter-Dispenser**

The Diluter Dispenser is an economical automatic laboratory dispenser designed to accurately deliver metered volumes of liquids. Up to four individual syringes, ranging in size from 1cc to 35cc, can be used to simultaneously deliver preset volumes from 0.1 to 30ml. Motor driven syringe pistons force preselected volumes of liquids through the system. Volumes are controlled both with the size of the syringe used and piston stroke. Benefits include (i) improved test performance by eliminating errors due to variation, (ii) rapid operation-each cycle is completed in less than 15 seconds. This is an ideal instrument for preparing multiple samples for subsequent analysis.

### **3.6 Digesdahl Digestion Apparatus and Analytical System**

This apparatus is designed to rapidly digest many organic and mineral

samples for subsequent analysis by spectrophotometric, turbidimetric, or titrimetric methods. Digestion procedures have been developed to determine nitrogen, phosphorous, potassium, calcium, iron, magnesium, manganese, lead, zinc in a variety of solids and liquid samples.

## 4. SOIL LABORATORY EQUIPMENT

### 4.1 Air Pychometer

The vacuum air pychometer is designed for the determination of porosity and density of solid bodies. From these data, specific weight and water content with appropriate calculations can be derived. These are specially constructed for use with soil sample rings.

In a vacuum bell an under pressure is created by lowering a connected mercury manometer. Depending on the gas volume in the bell more or less air will be drawn out, the amount being indicated by the mercury level with a scale of 0–115 ccm. With the gas volume in and total volume of the bell being known, the volume of solids is easily calculated.

### 4.2 CATI System

For *in situ* soil testing the CATI system is developed for automation of work with tensiometer i.e. measuring, data assembly as well as monitoring of irrigation projects.

### 4.3 Air Permeameter

By using the air permeameter it is possible to calculate the air permeability of (undisturbed) soil samples in sample rings. The intrinsic air permeability factor (Ki-factor) offers detailed information about:

- a) the presence of disrupting soil layers (caused by ploughing) which hinder speedy drainage and decrease aeration.
- b) the correlation between air permeability and various soil-characteristics, such as pore volume, granular composition, moisture percentage, air percentage etc.
- c) the vertical air permeability.
- d) the horizontal air permeability.
- e) the correlation between water permeability and air permeability.

This information can be used to determine the most effective manner of soil improvement, advice for the maintenance of field and site use.

## 5. GEO-HYDROLOGICAL EQUIPMENTS

### 5.1 Electronic Sensor Recorder

This instrument is useful for permanent measurement registration of water levels in rivers, lakes, observation pipes etc, and also at locations where floats cannot be used. The vented gauge pressure transducer with its small diameter (17.5mm) is very well suited for measurements in small diameter ground water monitoring tubes. The data-logger has a flanged rim which allows permanent installation inside the bore tube so that the whole is unobtrusive in the field. It is also very useful in pumping tests.

### 5.2 Gas Lift Water Sampler

Gas Lift Water Sampler is very suitable for frequent sampling at great depths. Sampling can be done in auger tubes and in narrow monitoring pipes for:

- a) Chemical analysis,
- b) Biological and bacteriological analysis.

Because of its measurements and independence of atmospheric pressure, this sampler allows for a wide range of sampling eg:

- a) at almost any depth,
- b) from tubes and auger holes with small dia (min  $\pm$  36 mm)
- c) from a tube or borehole without having to raise the sampler in between measurements.
- d) under anaerobic circumstances.

The standard set is suitable for sampling up to 40m depth.

### 5.3 Rod Operated Beaker Sampler

This apparatus is light weight and easy to use for taking samples of undisturbed submerged soils. With the prevailing sampling method, this apparatus is suitable for almost every kind of sediment varying in consistency from very watery and incohesive to consolidated sands. The transparent sample tubes have an internal diameter of 57mm. The samples can be taken in sample tubes with different lengths with a maximum sampling depth of 5 metres.

The beaker sampler can be used very successfully for:

- sampling of very weak soil layers on behalf of general soil research

and environmental studies.

- sampling in rivers, canals, harbours, lakes, paddy fields and so on.
- sampling in mud barges for volume weight determination.
- sediment sampling for geo-hydrological research.

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