INSTRUMENTATION FOR LAKE STUDIES

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Three Days Training Course on
HYDROLOGICAL INVESTIGATIONS FOR CONSERVATION AND MANAGEMENT OF LAKES
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INSTRUMENTATION FOR LAKE STUDIES

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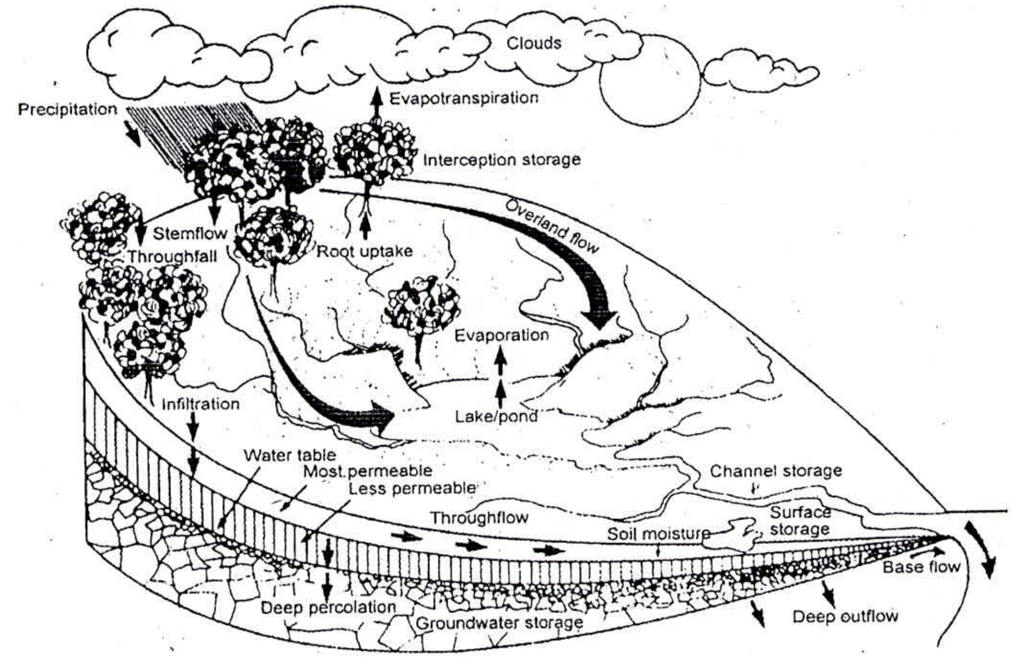
WATER IN A WATERSHED



Water is required for:

Drinking,
Cleaning,
Crop production,
Industry,
Bathing
Hygene & sanitation
Agro-forestry
Recreation

Water affects:

Habitation,
Vegetation,
Biodiversity,
Economy
Land use
Soil
Natural hazards

MONITORING IN LAKE STUDIES

Lake monitoring has become an essential part of lake management

- Physical
- Chemical, and
- Biological aspects of a lake ecosystem

Lake monitoring may provide early warning signs of ecosystem degradation resulting from contaminant inputs, nutrient addition, sediment runoff, and overuse of the resource

Monitoring a lake is the most effective means of keeping track of possible impacts and ecological status

Once a monitoring protocol is designed, instruments are required to collect the desired data

A lake has its own processes with a complete array of plants, animals, and microorganisms.

Lake ecosystem is greatly influenced by factors outside its immediate basin.

Weather, climate, atmospheric inputs, hydrology, and land use practices exert influence on lakes.

Lake water usually originates far from the actual basin and flows into the lake via streams and rivers, permeates the terrestrial sediments in the form of groundwater or falls in the form of precipitation.

Aside from water transport, materials also reach a lake through aerial transport.

Nutrients, sediments, biological materials, and harmful contaminants may all be carried through the air and settle into the lake basin.

Gases arising from bottom sediments can also dissolve and influence water quality.

IMPORTANT LAKE PARAMETERS

Catchment characteristics: area, topography, runoff.

Weather parameters: precipitation, ET losses, air temperature and humidity, solar radiation.

Hydrologic parameters: lake level, evaporation losses, infiltration rate.

Depth profiles: temperature, dissolved oxygen, pH, specific conductance, and turbidity measurements through the depth of the water column.

Readings are taken at the water surface and then about one-meter intervals to the lake bottom.

Variables measured in a depth profile change very rapidly, so frequent sampling is necessary.

In order to characterize the lake's extent of stratification and the changes within the water column, lake profiles should be taken at least once a month.

- DO- critical, used as a quick indicator for many parameters in the lake system.
- Temperature- provides insight for what organisms may inhabit the lake based on thermal tolerance.
- Turbidity- indicate high volumes of plankton in the water column or high suspended sediments, which in turn affect the scatter of light.
- Specific conductance and pH- both measure the amount of ions in the water, which has to do with buffering capacity and acidity.

HYDROLOGIC INSTRUMENTATION

Important question pertaining to hydrological instrumentation in general are:

- Why ?
- What ?
- How ?

HYDROLOGIC MEASUREMENTS FOR LAKE STUDIES

In the Catchment

- precipitation, runoff,
- Solar/terrestrial radiation,
- air temperature and humidity,
- wind speed and direction,

In the Lake

- evaporation,
- lake level,
- water quality

Choice/Selection of Instruments

Types of instruments to be specified primarily depends on:

- Objectives of the study
- Characteristics of the hydrological systems

Choice/selection of instruments also depends on:

- Site conditions
- Frequency of service
- Expected range of variation
- Mode of data collection, storage and retrieval
- Length of operation (should be able to withstand seasonal variations, including extremes)
- Availability of funds

IMPORTANT ISSUES IN HYDROMET INSTRUMENTATION

Selection of equipment:

- Proper specs (resolution, accuracy, technology)
- Power
- Manual/automated
- Data storage (chart/on-board memory/removable memory)
- Data transmission

Failure of instruments or ineffective monitoring

- Faulty instruments
- Improper site selection
- Inadequate budget for operation & maintenance
- Untrained, insincere manpower
- Lack of routine maintenance
- Improper data recording and/or storage

What should be done?

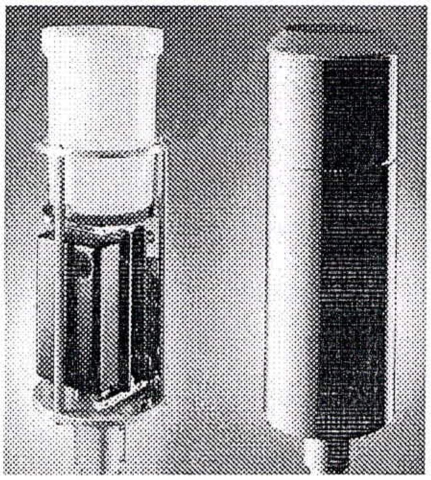
- Objectives of monitoring
- Spatial and temporal coverage
- Parameters to be monitored, frequency of observation & desired resolution and accuracy
- Location of site & site conditions
- Availability of power (mains/battery/SPV)
- Availability of manpower (manual/semi-automated/automated)
- Safety of equipment
- Inventory of spares and consumables & small setup for minor repairs
- Budget for operation & maintenance
- Training of manpower
- Data recording formats
- Preparation of database

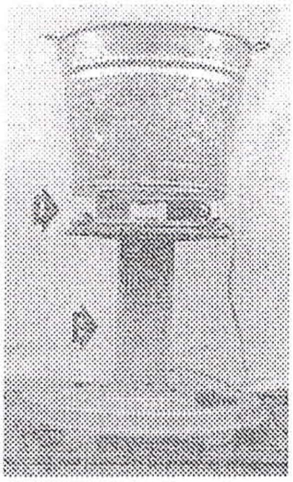
Rainfall

Raingauge

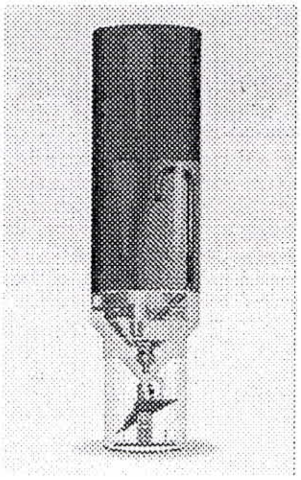
- Non-recording or standard raingauges
- Recording raingauges (including sensors)
- Storage type raingauges

Symon's ORG :
collection area=200cm2, For 25mm RF
Tipping Bucket : (0.2mm/tip)
Weighing :
(weight→ elect signal thru load-cell)

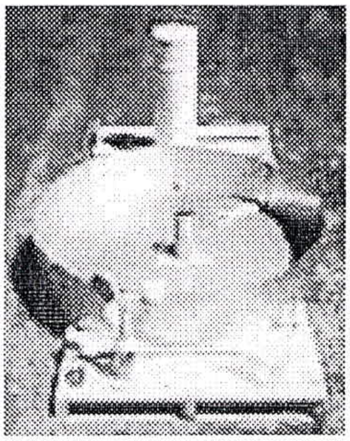




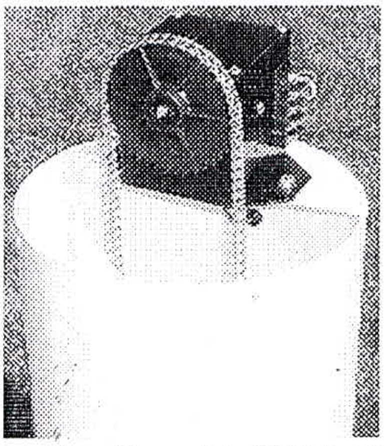
Pluvio Gauge



Evaporation

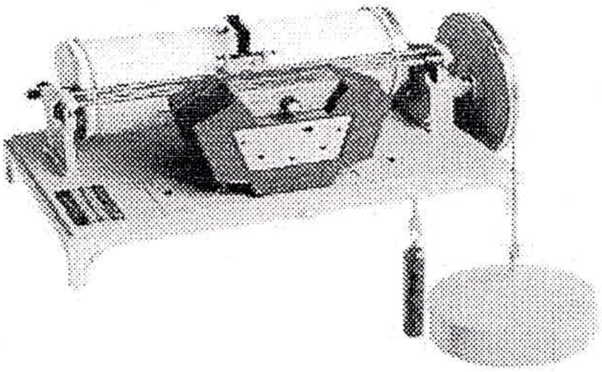


Evaporation Station graduated hook gage set on a Stillwell

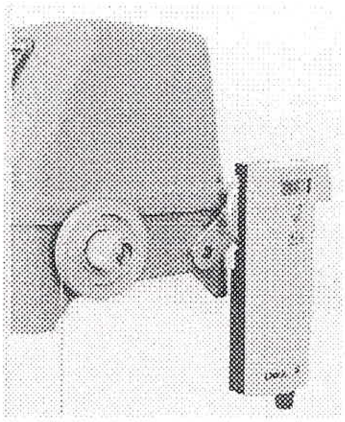


Evaporation Gauge 0 to 6" (0 to 150 mm) @ accuracy of ±0.015

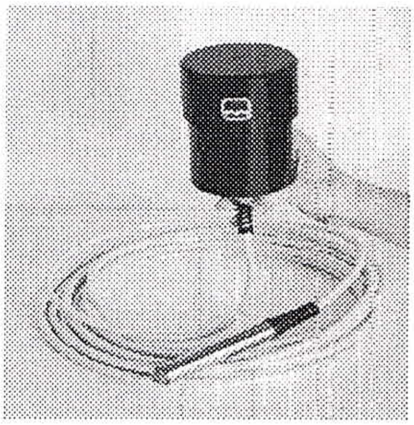
Water Level



Water stage recorder (analogue/digital)

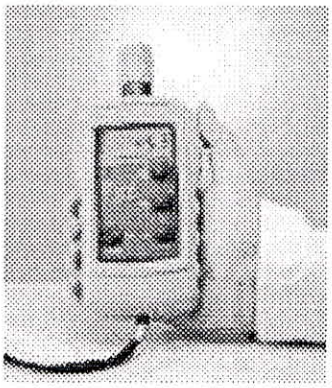


Incremental Shaft Encoder

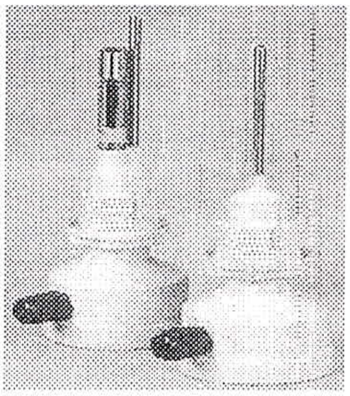


Pressure sensor

Air Temperature and Humidity



Thermo-hygrometer
0 to 60°C & 10%-95%

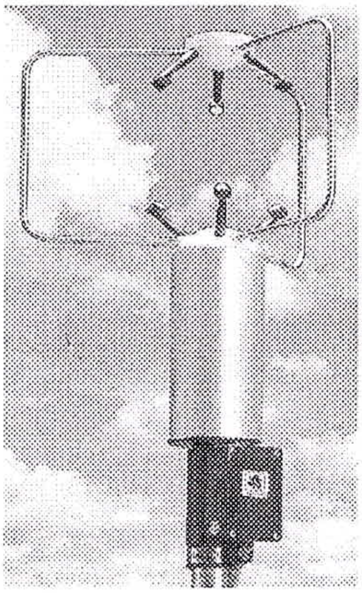


RH/Air Temperature Sensors

Non-recording instruments (thermometers)

Wind Speed and Direction

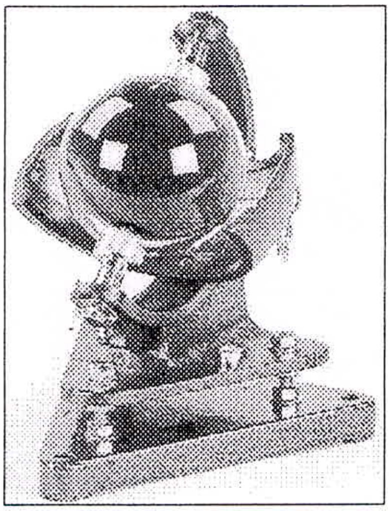
Anemometer-Cup: for wind speed
WS sensor: a helicoid shape propeller
WD sensor: a potentiometer-vane assembly



Ultrasonic Wind Sensor

Solar Radiation

Sunshine Recorder: sun's rays are focused by a glass sphere to intense spot, burns a trace of length proportional to the duration of sunshine on a special card

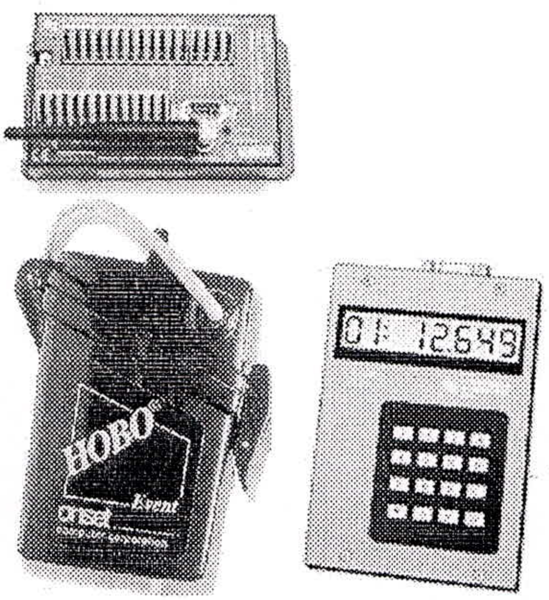


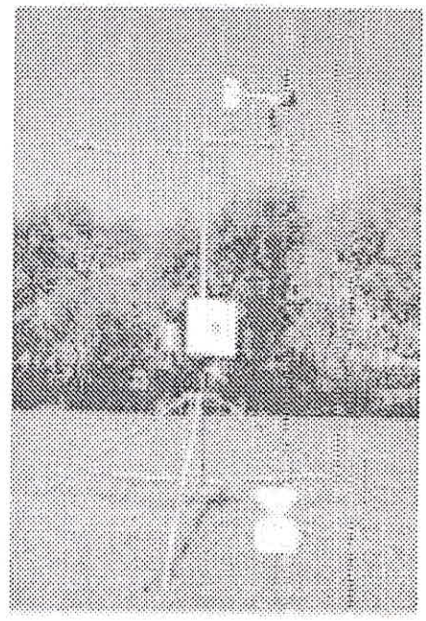
Photosynthetically Active Radiation (PAR) Sensor : measures photosynthetic photon flux density (PPFD) light in the 400 to 700 nm waveband

Pyranometer: silicon photovoltaic cell absorbs radiation from 0.35-1.15 microns, & converts this light energy into electrical energy

Automated Weather Station

It is a combination of different sensors for continuous, automated monitoring of meteorological parameters such as air temperature, humidity, atmospheric pressure, wind speed and direction, surface/sub surface temperature, rainfall or snowfall, sunshine, solar radiation etc.





Data Loggers

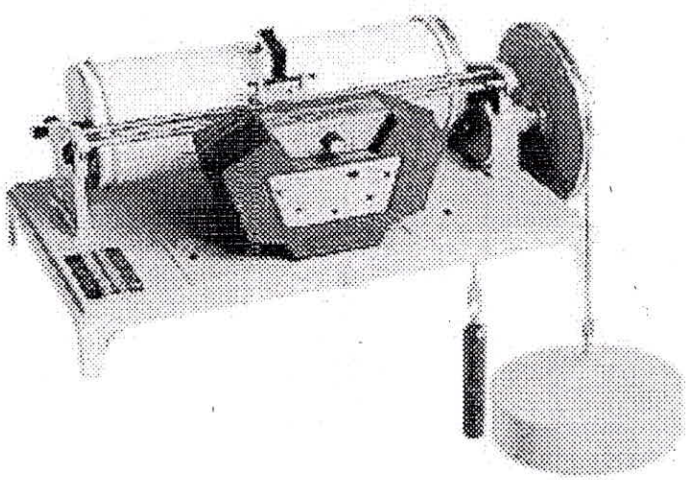
- DL is an electronic device that records the output of sensors: rainfall, discharge, temp., humidity, evap., solar radiation, wind, etc.
- can also control other devices according to the measurements made by the sensors, and carry out calculations and send messages
- DL often used in remote locations where there is no mains electricity
- Efficient & compact DLs are available at Rs. 5,000-15,000

Choice of a Data Logger

- What physical measurements are needed?
- What type of sensors will be needed and what kind of signal (output) do these sensors give?
- How frequently these measurements are needed?
- Control on any external devices is needed?
- Need to process the data to reduce the number of measurements stored?
- Where will the data logger be located? Does it need environmental protection? What about power?
- Methods to communicate with the data logger?

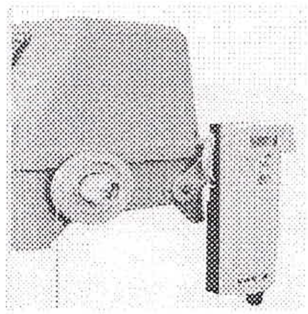
Recording Type Chart Recorders

Recording gages track changes in the water surface with respect to time, eliminating the need for regular site visits to read the gage. Capture more variability in the range of discharges, including extreme events, because water level is continuously recorded.



Incremental Shaft Encoder

Uses a rotating magnet and Hall-Effect device to measure the liquid levels. Useful for river stage, tide variation, precipitation, flood gate position, etc. Reliable product with a long life expectancy and low power consumption. Excellent for use in remote locations requiring solar or battery power.



Potentiometer Sensors

- Precision, multi-turn potentiometers used to convert upward/downward movement of a float-pulley mechanism to voltage
- For measurement of relatively small level changes (e.g., flows through a flume or over a weir)
-

Capacitance Sensors

- For measurement of relatively small level changes (e.g., flows through a flume or over a weir)
- Probe is immersed in water and as water level varies, capacitance of probe changes
- Sensitive towards changes in conductivity of water, and is not suitable for long-term continuous use
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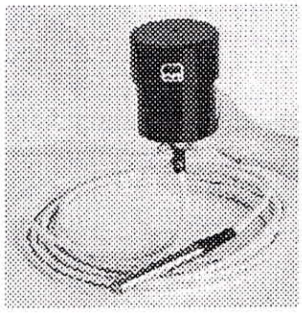
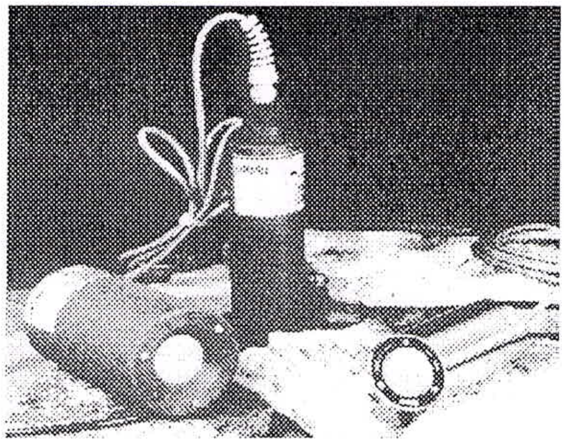
Pressure Sensors

- Constructed using piezo-electric silicon based transducers with calibration, temp. compensation, and signal conditioning.
- Relatively low-cost, and reliable choice for monitoring networks



Ultrasonic Sensors

- Senses the time of flight of an ultrasonic pulse from a transmitter to the surface of the water and back to a receiver, the sensor either being above the water looking down or in the water looking up .
- 'Non-contacting' technique.
- Useful in influent/effluent measurement at wastewater treatment plants using standard open channel flumes and weirs.



AWLR-Housing

Secchi Disk

A Secchi disk reading can provide information about water clarity from which characteristics such as turbidity and productivity can be inferred. The more phytoplankton or suspended sediment in a lake, the lower the Secchi disk reading. In coordination with other water quality measuring devices, the Secchi disk provides even more information about lake quality.

The Secchi disk is a round, flat disk painted with alternating black and white quadrants that was developed in the 19th century by an Italian astronomer named Secchi.

The disk is lowered into the water on the shady side of a boat, and at the point at which the disk is no longer visible, the depth is recorded. The disk is then raised until it becomes visible again, and that depth is also recorded. The average of these two depths is the Secchi depth. Eutrophic lakes may have Secchi depths of only 0-2 meters, and very clear, oligotrophic lakes may have Secchi depths closer to 20-30 meters.

Secchi depth changes over the course of seasons within an individual lake with algal blooms, storm turbulence, and seasonal plankton fluctuations.

Water Samplers

Instruments have been developed for sampling at discrete sampling depths or for collecting a composite sample representative of the entire water column.

Discrete depth samplers include the Kemmerer sampler, Van Dorn sampler, and a simple weighted bottle with a cork.

Kemmerer and Van Dorn samplers are lowered to the specified sampling depth in an open position, and then a weighted messenger on the rope is released. This triggers the sampling device to close at that depth, and the sample can be brought to the surface.

Weighted bottle is simply lowered with a cork in place, and when the desired depth is reached, the cork is removed by tugging on an attached rope.

Automated samplers can be programmed to collect samples several times in an hour or every few hours. Using automated samplers for chemical analysis has many advantages, but the bottles must be collected fairly often if the parameters being measured are likely to degrade over time.

Sediment Chemistry

Sediment chemistry can provide information about pollution that has accumulated in the lake over time. Many organisms or chemical compounds are broken down through biodegradation and decomposition, but many heavy metals, pesticides, and organic and inorganic pollutants remain intact in the sediment. Sediment chemistry changes very slowly, particularly heavy metals and pesticides, so sampling does not need to take place even every year.

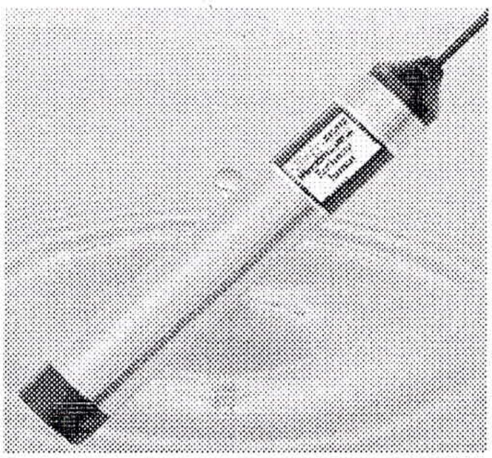
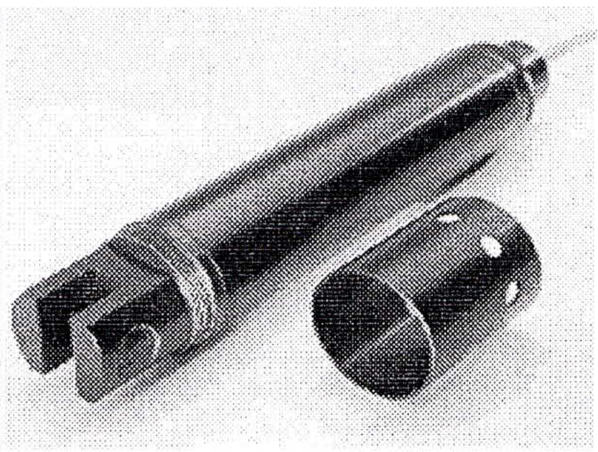
The sampling device is typically deployed in an open position, lowered to the sediment surface, and then triggered to snap shut– thereby grabbing a sediment sample. The instrument is then raised to the surface and emptied into a bucket or a bucket fitted with a screen bottom for benthic macroinvertebrates or a sample jar for sediment chemistry.

Common benthic samplers include the Ekman, ponar, and Petersen samplers. A heavier sampling device, such as the ponar sampler, will allow collection of a deeper sample. Sampling in larger or harder sediments often requires the heft of a ponar sampler to penetrate the benthos. Ponar sampling is often the best choice for sandy substrates.

Another option for sampling sediment is a core sampler. With a core sample, parameters can be measured along a depth gradient.

Turbidity Measurement

- Turbidity measures the attenuation or scattering of a light beam by suspended solids (particulate and dissolved) in the water column
- Slight changes in TSS concentration have large effects on a turbidity reading
- SS concentration/turbidity relationship must be developed for each measurement station, & checked periodically to detect changes over time
- SS concentration- turbidity regression may provide a prediction equation

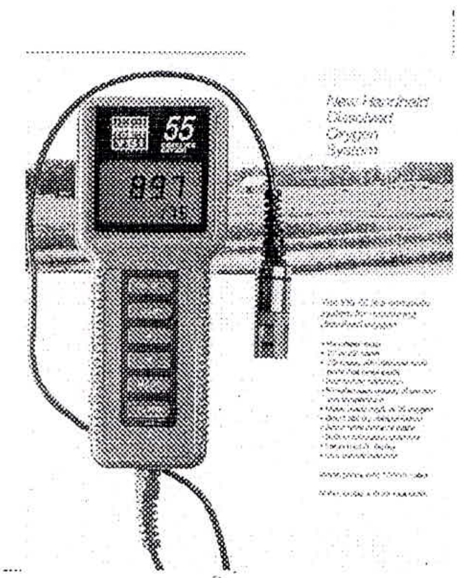



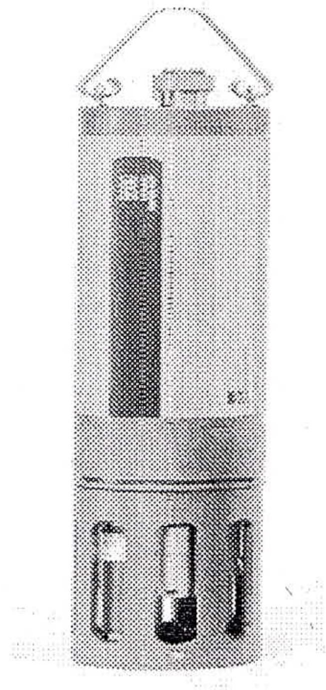
Water Quality

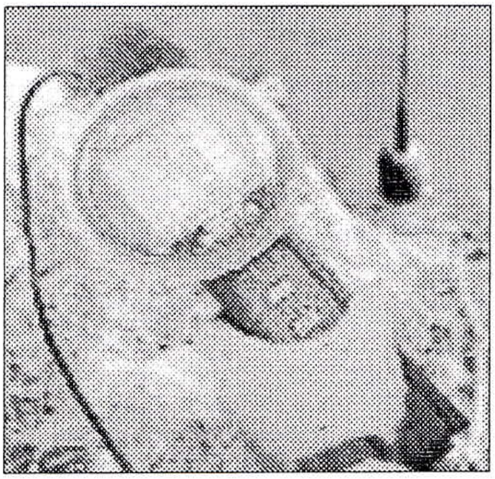
- Quality of a water body (stream, river, lake or estuary) assessed by examining physical, chemical and biological characteristics
- Common WQ parameters to be measured/ recorded: temp., conductivity, DO, pH, turbidity, salinity, BOD, TDS, and specific components such as sulfates, nitrates, calcium, etc
- Water samplers collect samples at various depths and locations for water quality analysis
- WQ parameters can be evaluated at a gaging station continuously and recorded with a data logger
- Single parameter water quality meters allow quick, accurate measurements in the field
- Meters have a probe with cable from the water into the stream/lake or have a cup in the meter to hold a sample,
- Also these can be used with a flow through chamber for multiple meters to analyze a sample pumped through it
- Multi-parameter water quality meters offer advantage of one meter, which can

simultaneously monitor several parameters at once from a hand-held meter with probe suspended by cable from the meter

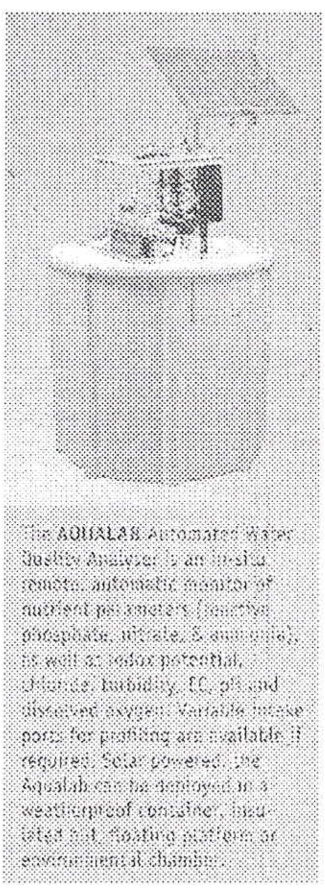
- A Sonde type multi-parameter meter is deployed in the river or lake for short or long-term recording
- A multi-channel data logger at the gaging station can be equipped with water quality sensors that can be deployed in the river with cable running to datalogger in the gage house

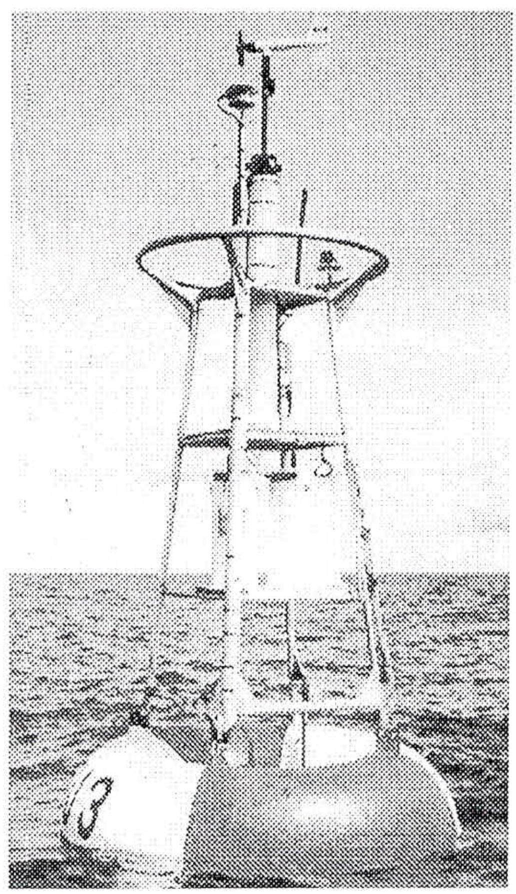


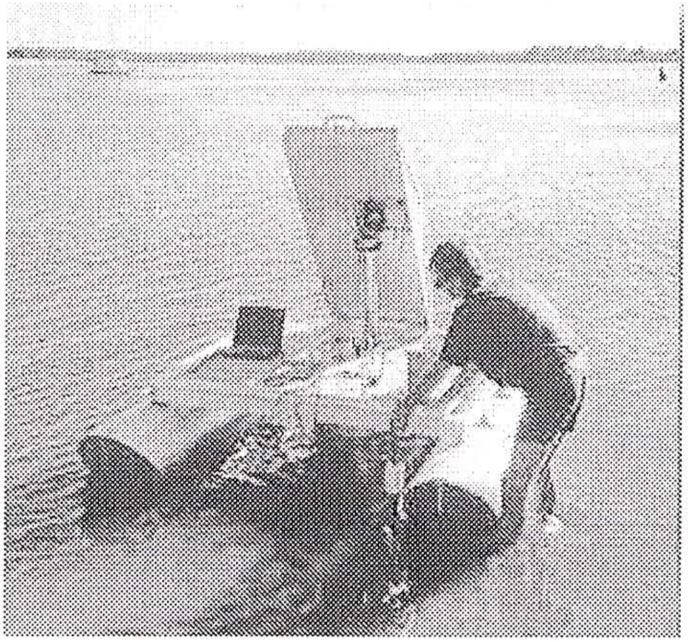




FLOATING PLATFORMS







REFERENCE

Meredith Becker Nevers and Richard L. Whitman. "Lake Monitoring Field Manual" U.S. Geological Survey, Lake Michigan Ecological Research Station 1100 N. Mineral Springs Rd. Porter, IN 46304