Ministry of Higher Education and Scientific Research
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Chemical Engineering Department

Environmental Instrumentation & Analysis

For Third Class Students
(Chemical Engineering and Environmental Pollution Branch)

By

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Environmental Instrumentation & Analysis:

1. Total Solid (TS),Total Suspended Solids (TSS) and Total Dissolved Solids (TDS):

<u>Total solids</u> is the matter (suspended or/and dissolved solids) that remains as residue upon evaporation and drying of a known volume of a water sample at (103−105) °C for 24 hrs. It is expressed as (T.S) and reported in terms of mg/l. Domestic waters with high solid content are of inferior palatability and unsuitable for many industrial applications.

<u>Total dissolved solids (Filterable residue):</u> are the solids dissolved in water, consist mainly of inorganic salts, small amounts of organic matter and is expressed as (T.D.S) and reported in terms of mg/l. It refers to the material that passes through filter paper No.1, and the filtrated water is dried at (103−105) °C for 24 hrs.

<u>Suspended solids (Non-filterable residue):</u> can be defined as un-dissolved matter such as bacteria, algae, fungi, silt and clay. It is referred as (T.S.S) in mg/l and represents the remaining material on the filtration membranes which is also dried at the same temperature.

Total Suspended Solids (TSS) is a water quality parameter used for example to assess the quality of wastewater after treatment in a wastewater treatment plant. It is listed as a conventional pollutant in the U.S. Clean Water Act. This parameter was at one time called non-filterable residue (NFR), a term that refers to the identical measurement: the dry-weight of particles trapped by a filter, typically of a specified pore size. However, the term "non-filterable" suffered from an odd (for science) condition of usage: in some circles (Oceanography, for example) "filterable" meant the material retained on a filter, so non-filterable would be the water and particulates that passed through the filter. In other disciplines (Chemistry and Microbiology for examples) and dictionary definitions, "filterable" means just the opposite: the material passed by a filter, usually called "Total dissolved solids" or TDS. Thus in chemistry the non-filterable solids are the retained material called the residue.

Total Dissolved Solids (TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular (colloidal sol) suspended form. Generally the operational definition is that the solids must be small enough to survive filtration through a filter with two-micrometer (nominal size or smaller) pores. Total dissolved solids are normally discussed only for freshwater systems, as salinity includes some of the ions constituting the definition of TDS. The principal application of TDS is in the study of water quality for streams, rivers and lakes, although TDS is not generally considered a primary pollutant (e.g. it is not deemed to be associated with health effects) it is used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants.

1.1 TDS Meter

TDS Meter indicates the Total Dissolved_Solids (TDS) of a solution are materials in the water that will pass through a filter with a 2.0 μm or smaller nominal average pore size, i.e. the concentration of dissolved solids in it. Since dissolved ionized solids such as salts and minerals increase the conductivity of a solution, a TDS meter measures the conductivity of the solution and estimates the TDS from that.

TDS meter typically displays the TDS in parts per million (ppm). For example, a TDS reading of 1 ppm would indicate there is 1 milligram of dissolved solids in each kilogram of water.

Purpose of Instrument:

Hanna Instruments offers a wide variety of instrumentation for measuring Conductivity EC, pH and TDS, as shown in Fig. (1).

Fig. (1)

2. Physical properties of river water: (Conductivity, pH, Turbidity)

2.1 Conductivity Meter

Conductivity instrument can be widely used in the areas such as petroleum chemical industries, biomedicine, waste water treatment, universities and research institutes. The conductivity of a solution is a measure of its ability to carry a current and varies both with the number and type of ions the solution contains. The electrodes are usually made of platinum metal. An alternating current is applied to the outer pair of the electrodes. The potential between the inner pair is measured. Conductivity could in principle be determined using the distance between the electrodes and their surface area using the Ohm's law but generally, for accuracy, a calibration is employed using electrolytes of well-known conductivity.

Conductivity is reciprocal of (The specific resistance (i.e. resistivity) (Ω.cm)) is a numerical expression of the ability of a water sample to carry an electric current, it depends on:

1. Concentration and type of ionized ions existing in the water.
2. Temperature affecting the movement and direction of ions flow (1°C increase cause 2% increase in electrical conductivity).

The standard unit is ohms.cm. Its advantage is used in water analysis to obtain a rapid estimate of the dissolved content in a water sample.

The dissolved solids = f * electrical conductivity.

Where f is a factor depends on ion components and temperature in the solution. The value of f lies within (0.55−0.9).

Purpose of Instrument:

It measures the electrical conductivity in a solution the measuring range of instrument is $(0 \sim 2X10^5)$ µS/cm and the constant of the electrode $(1.007\ cm^{-1})$, as shown in Fig. (1).

Fig. (1)

2.2 pH Meter

pH meters are usually used to measure the pH of liquids, though special probes. Basic potentiometric pH meters simply measure the voltage between two electrodes and display the result converted into the corresponding pH value. They comprise a simple electronic amplifier and a pair of probes, or a combination probe, and some form of display calibrated in pH. The probe is the key part: it is a rod-like structure usually made of glass, with a bulb containing the sensor at the bottom. Frequent calibration with solutions of known pH, perhaps before each use, ensures the best accuracy. To measure the pH of a solution, the probe is dipped into it.

Probes need to be kept clean of contamination as far as possible, and not touched by hand. Probes are best kept moist with a medium appropriate for the particular probe (distilled water, which can encourage diffusion out of the electrode, is undesirable) when not in use.

pH is a term used to express the intensity of the acidity or alkalinity of a solution. It is a way to measure the hydrogen-ion concentration. It is expressed as the logarithm of the reciprocal of the hydrogen ion activity in molar per liter. pH is important for the control of water treatment such as coagulation, softening and disinfection. In the biological treatment of wastewater the pH is favorable in the control of corrosion.

Purpose of Instrument:

pH Meter is a device uses along potentiometrically measuring the pH, which is either the concentration or the activity of hydrogen ions, of an aqueous solution, as shown in Fig.(1).

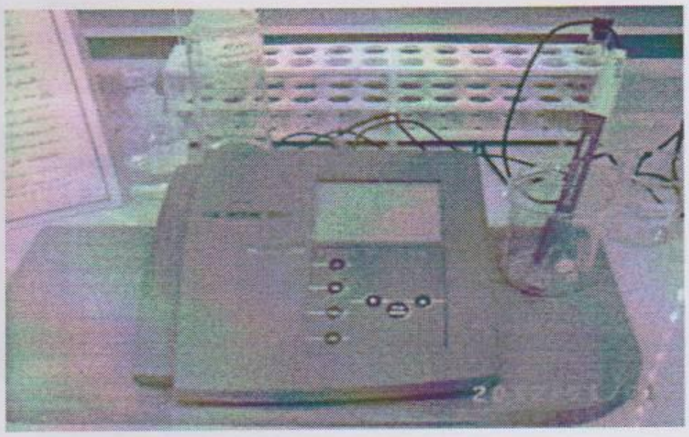

Fig. (1)

2.3 Turbid Meter

Turbidity (or haze) is also applied to transparent solids such as glass or plastic. In plastic production haze is defined as the percentage of light that is deflected more than 2.5° from the incoming light direction

The propensity of particles to scatter a light beam focused on them is now considered a more meaningful measure of turbidity in water. Turbidity measured this way uses an instrument called a nephelometer with the detector set up to the side of the light beam. More light reaches the detector if there are lots of small particles scattering the source beam than if there are few. The units of turbidity from a calibrated nephelometer are called Nephelometric Turbidity Units (NTU). To some extent, how much light reflects for a given amount of particulates is dependent upon properties of the particles like their shape, color, and reflectivity.

What causes turbidity?

There are various parameters influencing the cloudiness of the water. Some of these are:

- Phytoplankton.
- Sediments from erosion.
- Resuspended sediments from the bottom (frequently stir up by bottom feeders like carp).
- Waste discharge.
- Algae growth.
- Urban runoff.

Turbidity is a principle physical characteristic of water which is an expression of the optical property that cause light to be scattered and absorbed by particles rather than transmitted in straight lines through a water sample. Also; turbidity is the measure of relative clarity of a liquid. Clarity is important feature when production drinking water for human consumption and in many manufacturing uses. Once consider as a mostly aesthetic characteristic of drinking water, significant evidence exists that controlling turbidity is a competent safeguard against pathogens in drinking water.

<u>Typical sources of turbidity in drinking water:</u>

Waste discharges runoff from watersheds, especially those that are disturbed or eroding algae or aquatic weeds and products of their breakdown in water reservoirs, rivers, or lakes; humic acids and other organic compounds resulting from decay of plants, leaves, etc.

High iron concentrations give waters a rust-red coloration (mainly in ground water under the direct influence of surface water); air bubbles and particles from the treatment process (e.g., hydroxides, lime softening).

<u>Turbidity Test by Jackson Candle Turbid meter on Raw Waters</u>

(For turbidity Range between 25−1000 mg/l)

Apparatus:

Jackson's turbid meter in a portable wooden box (Fig. 2.3) containing:

1. Cylindrical base stand fitted with a candle, or a switch and bulb with dry battery set (torch cells).
2. Metallic cylinder (container) to be fitted on the base stand.
3. Calibrated glass tube to be inserted into the upper metallic cylinder.
4. A table on a white regular plate fixed to the base stand, giving the turbidity in ppm, corresponding to different reading of the graduated glass cylinder.

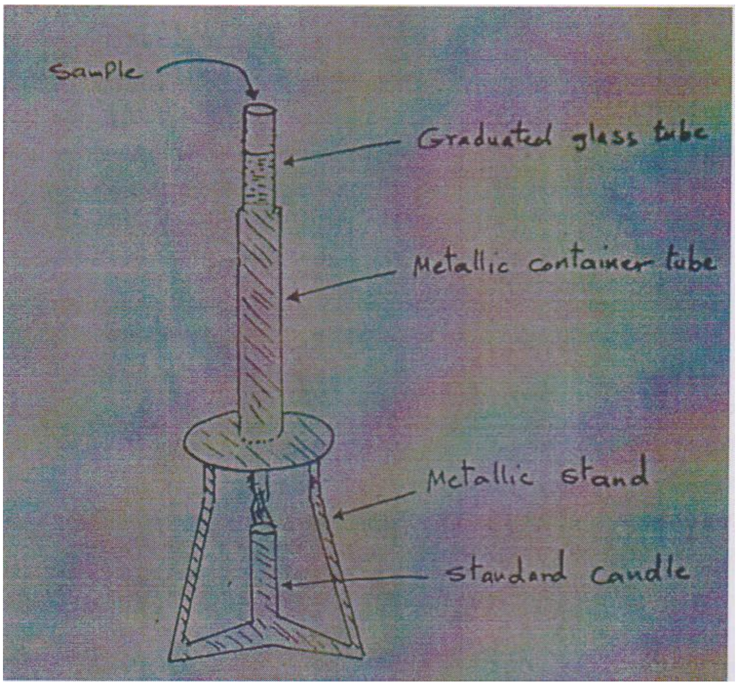

Fig. 2.3: View of Jackson candle turbid meter

Turbidity Test by Nephelometer on Raw Waters

A second method measuring turbidity is by using the principle of scattering of light rather than the principle of absorption of light. In such an instrument, the sample "scatters" the light that impinges on it. The scattered by the light is then measured by putting the photometer at right angles to the original direction of the light generated by the light source. This measurement of light scattered at 90° angles is called nephelometry; and the unit of turbidity in such an instrument, called a nephelometer (Fig. 2.4), is known as the nephelometric turbidity unit (NTU). It is characterized by sensitivity, precision, and applicability over a wide range of particle size and concentration. The higher the intensity of scattered Light, the higher is the turbidity.

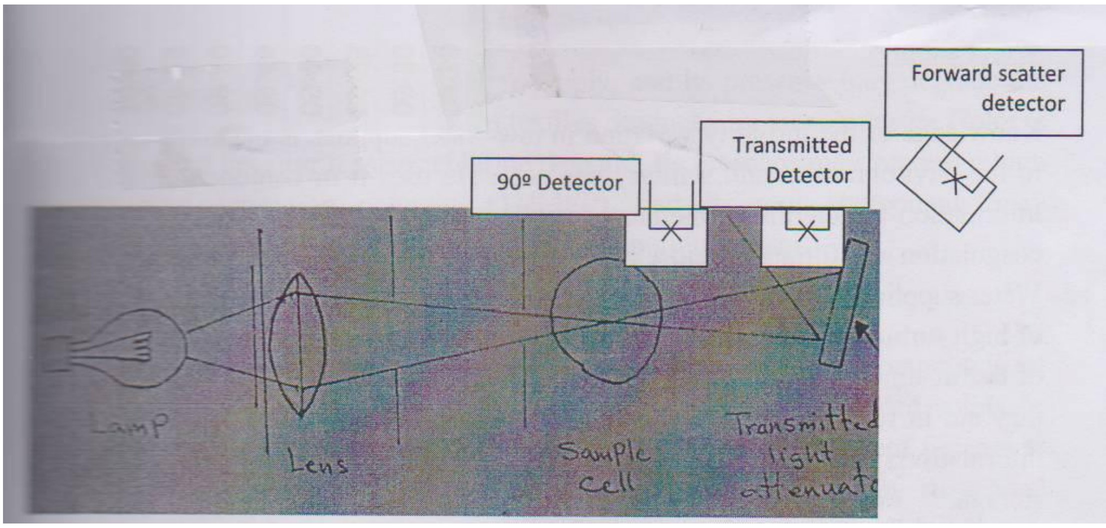

Fig. 2.4: Light path diagram for nephelo meter

<u>Turbidity's significance to human health</u>

Excessive turbidity, or cloudiness, in drinking water is aesthetically unappealing, and may also represent a health concern. Turbidity can provide food and shelter for pathogens. If not removed, turbidity can promote re-growth of pathogens in the distribution system, leading to waterborne disease outbreaks, which have caused significant cases of gastroenteritis throughout United States and the world. Although turbidity is not direct indicator of health risk, numerous studies slow a strong relationship between removal of turbidity and removal of protozoa. The particles of turbidity provide "shelter" for microbes by reducing their exposure to attack by disinfectant. Microbial attachment to particulate material or inert substances in water systems has been documented by several investigators and has been considered to aid in microbe survival.

Purpose of Instrument:

Turbid meter is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates, as shown in Fig. (1).

Fig. (1)

Application of turbidity data

Turbidity measurements are of particular importance in the field of water supply. They have limited use in the field of domestic and industrial waste treatment.

Water supply

Knowledge of the turbidity variation in raw-water supplies is of prime importance to the environmental and sanitary engineer. He uses it in conjunction with other information to determine whether a supply requires special treatment by chemical coagulation and filtration before it may be used for a public water supply.

Water supplies obtained from rivers usually requires chemical flocculation because of high turbidity. Turbidity measurements are used to determine the effectiveness of the treatment produced with different chemicals and the dosages needed. Thus they aid in selection of the most effective and economical chemical to use. Such information is necessary to design facilities for feeding the chemicals and for their storage.

Turbidity measurements help to gauge the amount of chemicals needed from day to day in the operation of treatment works. This is particularly important on "fleshly" rivers where no impoundment is provided. Measurement of turbidity is useful in controlling chemical dosage, so as to prevent excessive loading of rapid sand filters. Finally, turbidity measurements of the filtered water are needed to check on faulty filter operation.

3- Ion Selective Electrodes

Ion-selective electrode (ISE), also known as a specific ion electrode (SIE), is a transducer (or sensor) that converts the activity of a specific ion dissolved in a solution into an electrical potential, which can be measured by a voltmeter or pH meter. The voltage is theoretically dependent on the logarithm of the ionic activity, according to the Nernst equation. The sensing part of the electrode is usually made as an ion-specific membrane, along with a reference electrode.

Principle of ion-selective electrode (I.S.E.) An ideal I.S.E. consists of a thin membrane across which only the intended ion can be transported. The transport of ions from a high conc. to a low one through a selective binding with some sites within the membrane creates a potential difference, as shown in Fig. (2).

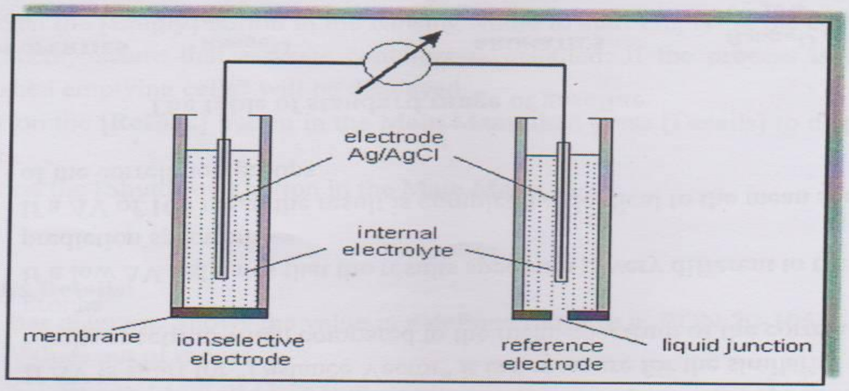

Fig. (2)

The use of Ion Selective Electrodes in environmental analysis offer several advantages over other methods of analysis.. First, the cost of initial setup to make analysis is relatively low. The basic ISE setup includes a meter (capable of reading millivolts), a probe (selective for each analytic of interest), and various consumables used for pH or ionic strength adjustments.

Purpose of Instrument:

Ion-selective electrodes are used in analytical chemistry research, where measurements of ionic concentration in an aqueous solution are required; this instrument as shown in Fig. (1).

Fig. (1)