

WATER QUALITY PARAMETERS AND STANDARDS

The parameters for water quality characterization are listed in Table 12.10. The permissible limits, as laid down by the United States Public Health drinking water standards (USPH) and Indian Standard Institution (ISI) are listed for comparison. These refer to domestic water supplies for drinking water (Table 12.11). The ISI values, available for only a few parameters, are much higher than those for USPH, obviously for no good reasons.

Table 12.11 Parameters for water quality characterization and standards (Domestic water supplies)

Parameters	USPH Standard	ISI Standard (IS: 2296-1963)	
	2	3	
1 Colour, odour, taste	Colourless, odourless, tasteless	—	
<i>Inorganic Chemicals</i>		6.0-8.5	6.0-90
pH	300 mmho cm ⁻¹	—	
Specific conductance	4.0-6.0 (ppm)	3.0	
Dissolved oxygen (D.O.)	500	—	
Total dissolved solids	5.0	—	
Suspended solid	250	600	
Chloride	250	1000	
Sulphate	0.05	0.01	
Cyanide	<10	—	
Nitrate + nitrite	1.5	3.0	
Fluoride	0.1	—	
Phosphate	0.1 mg l ⁻¹ (ppb)	—	
Sulphide	0.5	—	
Ammonia	1.0	—	
Boron	100	—	
Calcium	30	—	
Magnesium	0.05	0.2	
Arsenic	1.0	—	
Barium	0.01	—	
Cadmium	0.05	0.05	
Chromium(VI)	1.0	—	
Copper	<0.3	0.01	
Iron (filterable)	<0.05	—	
Lead	<0.05	—	
Manganese (filterable)	0.001	0.05	
Mercury	0.01	—	
Selenium	0.05	—	
Silver	5.0	—	
Uranium	5.5	—	
Zinc			
<i>Organics</i>			
COD	4.0	—	
Carbon CHCl ₃ extract (CCE)	0.15	—	
Methylene blue active substances	0.5	0.005	
Phenols	0.001	—	
Pesticides (total)	0.005	—	

Table 12.11 (Contd.)

Parameters	USPH Standard	ISI Standard (IS: 2296-1963)
1	2	3
Polycyclic aromatic hydrocarbons (PAH)	0.2 ppb (0.002 ppm)	
Surfactants	200	
<i>Radioactivity²</i>		
Gross beta	1000 pc/L	
Radium-226	3 pc/L	
Strontium-90	10 pc/l	<5000
<i>Bacteriological Parameters</i>		
Coliform cells/100 ml	100	
Total bacteria count/100 ml	1×10^6	

Sources: ¹The official journal of the European Committees, L 229, pp. 16-21 (1980) quotes figures close to USP standards. The 3 values are considerably on the high side, which remain open to question and these do not cover all parameters.

²All the units, except otherwise mentioned and pH, specific conductance and radioactivity, are in ppm, i.e., parts per million or mg/l. The radioactivity units are in picocuries/l, i.e., 10^{-12} curies/l (2.2 disintegrations $\text{min}^{-1} \text{l}^{-1}$).

Surface Waters

MEASUREMENT OF WATER QUALITY BY CHEMICAL AND PHYSICAL EXAMINATION OF WATER

Chemical and physical examinations for water analysis include following determinations

1. *Chemical substances affecting potability.*
2. *Chemical substances affecting health.*
3. *Measurement of toxic chemical substances.*
4. *Chemical substances indicative of water pollution.*

CHEMICAL SUBSTANCES AFFECTING POTABILITY COLOUR

This test is usually applicable to drinking water and potable water and is carried out by comparison with known colour standards. Colour in water may be due to the presence of suspended particles in suspension or due to certain mineral matter in solution. Even pure water is colourless and it has been found to have a pale green - blue tint in large quantities. The colour of a water sample is due to the substances present as fine colloids. Industrial effluents contribute colours to water supplies. Colour of water may be caused by iron, copper, manganese, metals, tannins, peat, humus, algae, weeds and protozoa. **The true colour can be estimated by visual comparison with platinum cobalt standard colour solution.** Colours can be estimated **visually or photo electrically.** Generally yellow colour indicates the presence of appreciable amounts of organic matter or chromium. The yellowish red colour indicates the presence of iron. The presence of peaty matter is indicated by red brown colour.

Colour is measured with an instrument known as **tintometer**. It has an eye piece having two holes. A slide of standard coloured water and the slide of water to be tested are observed through the two holes and both are compared. The unit of colour is measured on the platinum cobalt scale. The standard colour can be produced by dissolving 1 mg of platinum - cobalt in one litre of double distilled water. The number on the scale should not exceed 20 and should be preferably less than 10.

TURBIDITY

Turbidity in water is due to colloidal and extremely fine dispersions. Suspended matter such as clay, silt, finely divided organic and inorganic matter, plankton and other micro-organisms also contribute to turbidity. Generally, the more the turbidity, stronger is the sewage or effluent and the effects are worse. *So the degree of turbidity of a water course may be used as a measure of the intensity of pollution. Turbidity measurements are helpful to follow the course of self purification of rivers or streams. Turbidity can be measured by visual methods and instrumental methods such as absorptiometrically or nephelometrically.*

One of the methods by which turbidity is measured is by using a **turbidity rod**, which has a platinum needle. The rod is lowered into the water to be tested and the depth at which the wire disappears is noted. The reading gives the turbidity of water in ppm. Turbidity can also be measured by making use of **Jackson's turbidimeter**, which consists of a metal stand over which a metal container, is placed. A graduated glass tube is placed in the container and a standard candle is placed below the stand. Water is added into the glass tube and the flame is observed from the top. The depth of water in the glass tube at which the flame can not be seen is noted on the glass tube. This gives the turbidity of water in ppm. Jackson's turbidimeter is capable of measuring turbidity above 100 ppm. **For municipal, water supply the turbidity should not exceed 10 ppm.** The standard unit of turbidity is considered as that produced by one ppm of silica in the form of diatomaceous earth, Fuller's earth or bentonite, in distilled water. It may be removed either by settling or by centrifuging. Comparison can be made either directly with standards or by measuring the obscuring power against a light.

ODOUR

Disagreeable odours in water are due to the presence of microscopic organisms or decaying vegetation including algae, fungi, bacteria, actinomycetes and weeds. Sewage and industrial effluents cause offensive odours to receiving waters. The extent of odour depends upon the pH of water. The lower the pH the higher will be the amount of hydrogen sulphide produced. The presence of nitrogen, phosphorus and sulphur compounds, putrefaction of protein and organic matter, presence of sewage or trade wastes are the major causes of odour in polluted rivers.

Water in rivers, lakes and raw water storage reservoirs are affected by algal growth. For example, the protozoa dinobryon imparts a fishy odour in water. The algae oscillatoria and rivularia produce mouldy odour and **algae anabaena** a strong grassy odour. Mineral matters such as sand and clay when present in finely divided state produce a faint earthy taste and odour in water. Improper bituminous coating on mains gives off a tarry odour to water passing through it. In addition to chlorinous taste and odour produced by chlorination, chlorophenol and iodoform odours are also produced in water.

Determination of odour - For qualitative determination of odour, place 250 mL of the sample in a 500 mL wide mouth erlenmeyer flask and sniff the odour. This is cold odour quality at room temperature. To determine the hot odour quality take 250 mL sample in a 500 mL stoppered conical flask and heat to 58-60°C. Sniff the odour which may be :

- (a) Aromatic (b) Chlorinous (c) Chemical (d) Medicinal (e) Salty
 (f) Septic (g) Earthy (h) Peaty (i) Grassy (j) Metallic
 (k) Fishy (l) Disagreeable (m) Vegetable (n) Putrid (o) Bitter

The intensity of odour is expressed in terms of threshold odour number (TON)

Analysis of odour may be used to determine the effectiveness of deodourising process as a means of tracing contamination or leaks in industrial processes.

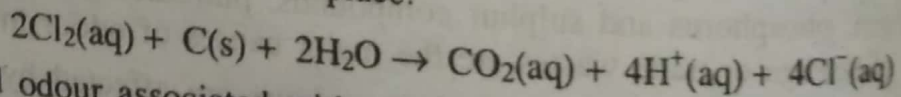
Elimination of odour- Odours in drinking water can be eliminated by the use of ozone, chlorine dioxide and activated carbon. Aeration is also an effective method for the removal of odour.

- > Taste and odour in water may be due to the presence of one or more of the following: (a) Dead or alive micro - organisms. (b) Dissolved gases such as O_2 , CO_2 , CH_4 etc and organic matter. (c) Mineral substances such as sodium chloride, carbonates and sulphates of calcium and magnesium elements such as Ca and Mg and iron compounds.
- > Tastes may also develop in the treatment process as a result of excess chlorine reaction with asphaltic or bituminous coatings in the water distribution pipes.
- > The odour of water changes with temperature and it may be classified as sweetish, grassy, fishy, vegetable etc.
- > Some of the treatments such as pre - chlorination, coagulation followed by filtration, dechlorination followed by dechlorination and use of chlorine dioxide can be used to remove colour, odour and taste to certain extent.

TASTE

Taste is always accompanied by odour. However, dissolved mineral matters in water may give taste but not odour. A faint bitter taste may be due to the presence of sulphate while an inky taste may be due to the excess of sodium bicarbonate. Water containing unusual salts may have a brackish taste. Dissolved gases, minerals, nitrates and carbonic acid make water tasteless.

One way to remove objectionable tastes and odours from water is to pass it through a filter bed containing activated charcoal, a finely divided form of carbon. The enormous surface area of this material (about 6 million cm^2/g) enables it to adsorb large quantities of various impurities, most of which are organic compounds held physically on the surface of carbon. In the presence of chlorine, the following reaction takes place.



The taste and odour associated with chlorinated drinking water can be eliminated by passing it through a filter bed. After the filter bed has been operated for about an year, most of the capacity of the bed can be reclaimed by heating to about $1000^\circ C$ in order to remove adsorbed organic impurities.

The usual dose of activated carbon varies from 5 - 20 ppm. The activated carbon is available in various trade names such as Darco, Nuchar etc. It is available in granular and powdered form. The activated carbon can be applied in the form of powder or as filter bed. The advantages of this method are :

- (a) It reduces the chlorine demand of treated water. (b) It removes the organic matter in water to a much greater extent. (c) It removes taste because of excess chlorine, H_2S and phenol. (d) Its overdose is harmless.

In addition certain special methods have also been used for the removal of colour, odour and taste. For example, the **aeration process** aims at bringing water in intimate contact with air. *The aeration of water also serves the following useful purposes.*

(a) *The bacteria may be killed to some extent because of agitation of water in the process of aeration.* (b) *In the process of aeration O_2 is absorbed and CO_2 is liberated. Thus removal of CO_2 results in less corrosion to pipes.* (c) *H_2S is easily removed as a result of aeration and hence odour due to this gas is removed.* (d) *Aeration also oxidises the iron and manganese present in water to certain extent.*

Four common methods of aeration have been used in the treatment of water.

(a) **Air diffusion** - In this method compressed air is passed through perforated pipes installed at the bottom of the tanks. The air bubbles while coming up from the bottom of tank come in close contact of water present in the tank and hence aeration is achieved. The air consumed per 1000 litres of water varies from 0.3 to 0.6 m^3 .

(b) **Cascades** - A cascade is a water fall and a simple cascade consists of three or four steps in series. The steps may be of concrete or metal. The water is allowed to fall through a height of about 1 to 3 metres during which water comes in close contact with the air and aeration is completed.

(c) **Spray nozzles** - In this method of aeration, CO_2 is removed from the water to the extent of 90% when water is sprinkled in fine jets through nozzles to a height of about 2.5 to 3.0 metres. The nozzles are generally operated at 0.07 to 0.14 N/mm^2 pressure.

(d) **Trickling beds** - In this method coke or slag beds are prepared and supported over perforated trays. The size of coke varies from 50 mm to 75 mm. The beds are arranged in vertical series and generally three beds are placed one above the other. The water is allowed to pass through perforated pipes placed at the level of top bed and then it is allowed to fall down from top bed to bottom bed. Aeration of water takes place during the trickling process.

Copper sulphate has also been used for removing odour, colour and taste from water. In addition it also controls the growth of algae, bacteria and some types of aquatic weeds etc. The copper sulphate ($CuSO_4 \cdot 5H_2O$) is available in powder form or crystal form. Its crystals are easily soluble in water and the usual percentage of copper is 25%. The dose of copper sulphate is about 0.50 to 0.65 ppm. Water containing this amount of copper sulphate is not unfit for drinking or industrial purposes. But it may be harmful to certain types of fish.

Odour of the water sample can also be tested at 20 - 25°C by making use of an instrument known as **osmoscope**. Odour is measured by adding small quantity of water to be tested at a time to 100 mL of fresh odour free water. The quantity of water at which the odour becomes detectable is known as **threshold odour number**. Thus if 10 mL of water to be tested is added to 100 mL of fresh odour free water for the odour to be detected, the **threshold odour number is 10**. **For municipal water supply, the threshold odour number should not be greater than 3.**

TEMPERATURE

Surface waters differ considerably in temperature between winter and summer. Temperature measurements are useful in detecting an unsuspected source of pollution, in calculating alkalinity and in industrial water supplies for heat transmission calculations.

HYDROGEN ION CONCENTRATION (pH)

pH, a measure of hydrogen ion activity, is used to express the intensity of acidic or alkaline

condition of a solution. It is also an important factor in water analysis since it enters into the calculation of acidity, alkalinity and processes like coagulation, disinfection and corrosion control. The pH of a sample can be determined electrometrically or colorimetrically.

Electrometric method for the determination of pH - Electrometric determination of pH involves the measurement of electromotive force (EMF) of a cell comprising an indicator electrode (glass electrode) responsive to hydrogen ions and a reference electrode (calomel electrode).

pH meters used for measurement- pH meters range from battery operated portable units to highly precise instruments. The accurate pH meter can read to ± 0.005 pH unit.

Measurement of pH- (i) First standardize the pH meter using a standard buffer solution of pH near that of the sample to be tested. Different buffer solutions can be prepared as follows :

pH 4 buffer solution- Dissolve 1.012 g. anhydrous potassium hydrogen phthalate in distilled water to 100 mL in a volumetric flask at 25°C .

pH 7 buffer solution- Dissolve 1.361 g. anhydrous potassium dihydrogen phosphate (KH_2PO_4) and 1.420 g. disodium hydrogen phosphate NaH_2PO_4 in distilled water and make up to 1000 mL in a volumetric flask.

pH 9 buffer solution - Dissolve 3.81 g borax ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$) in distilled water to 1000 mL.

(ii) Then check the electrode response by measuring the pH of another standard buffer solution having different pH.

Interpretation of the result - Based on pH values, following conclusions can be drawn.

- Waters having pH above 8 contain carbonates. It may be with or without bicarbonates.*
- Waters with pH value in the range of 4.5 to 8 contain no carbonates but contain bicarbonates and carbonic acid. Natural waters fall under this category.*
- Waters having pH value below 4.5 contain carbonic acid but not carbonates or bicarbonates.*
- The desirable pH range for drinking waters is 7.0 to 8.5.*
- pH in conjunction with total salinity, total alkalinity and temperature is used to determine whether a water is corrosive in nature or having scale forming tendencies.*

Knowledge of pH is essential in the selection of coagulants for water purification. For instance, aluminium sulphate is effective at pH 6.7, while ferrous sulphate coagulates well at a higher pH.

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