therefore, the biological treatment of industrial wastes usually requires supplemental addition of nitrogen compounds and other nutrients. The presence of potentially toxic compounds must be carefully considered in devising a treatment strategy.

2. Domestic wastes are treated by municipalities and derive from humans and their daily activities. They include ground garbage, laundry water, excrement, and often some industrial wastes that have been sewered into the municipal system. Domestic waste varies significantly with time in terms of flow and composition due to the periodic nature of human activity (e.g., flow decreases at night when most people sleep).

3. Agricultural wastes are produced by farm animals (e.g., manure) and include waste plants, such as straws. Agricultural wastes are usually carbon rich because of high cellulosic material content, although some wastes, such as poultry manure, are high in nitrogen.

Each of these waste materials has its own characteristics, and treatment methods vary depending on these characteristics.

Three major waste treatment methods are the following:

1. *Physical treatment* includes screening, flocculation, sedimentation, filtration, and flotation, which are usually used for the removal of insoluble materials.

2. *Chemical treatment* includes chemical oxidations (chlorination, ozonation) and chemical precipitation using $CaCl_2$, $FeCl_3$, $Ca(OH)_2$, or $Al_2(SO_4)_3$.

3. *Biological treatment* includes the aerobic and anaerobic treatment of waste water by a mixed culture of microorganisms.

Certain characteristics of waste water need to be known before treatment. Among them are (1) physical characteristics, such as color, odor, pH, temperature, and solids contents (suspended and dissolved solids), and (2) chemical characteristics, such as organic and inorganic compounds. Major carbon compounds in a typical industrial waste are carbohydrates, lipids–oils, hydrocarbons, and proteins. Other compounds, such as phenols, surfactants, herbicides, pesticides, and aromatic compounds, are usually in relatively small concentrations (<1 g/l) but are difficult to degrade by biological means. Among inorganic compounds present in waste water are nitrogenous compounds (NH_4^+, NO_3^-), sulfur compounds (SO_4^{2-}, S^{2-}, S^0, S_3^{2-}), phosphorus compounds (PO_4^{3-}, HPO_4^{2-}, $H_2PO_4^{1-}$), heavy metals (Ni^{2+}, Pb^{2+}, Cd^{2+}, Fe^{2+}, Cu^{2+}, Zn^{2+}, Hg^{2+}), and dissolved gases, such as H_2S, NH_3, and CH_4.

The carbon content (strength) of a waste-water sample can be expressed in several ways: *biological oxygen demand* (BOD), *chemical oxygen demand* (COD), and *total organic carbon* (TOC). Normally, a 5-day BOD value is reported. The BOD_5 is the amount of dissolved oxygen (DO) consumed when a waste-water sample is seeded with active bacteria and incubated at 20°C for 5 days. Since the amount of oxygen consumed is stoichiometrically related primarily to the organic content of waste water, BOD is a measure of the strength of waste water. This stoichiometric coefficient is not always known, since the composition of the organics is usually unknown. Also, some nitrogen-containing or inorganic compounds will exert an oxygen demand. If the only organic compound is