**Solute and water activity (halophiles, xerophiles, osmophilic)**

Water is the solvent of life, and water availability is an important factor affecting the growth of microorganisms. Water availability not only depends on how moist or dry an environment is but is also a function of the concentration of solutes (salts, sugars, or other substances) dissolved in the water that is present.

Solutes bind water, making it less available to organisms. Hence, for organisms to thrive in high-solute environments, physiological adjustments are necessary. Water availability is expressed in terms of **water activity (*a*w)**, the ratio of the vapor pressure of air in equilibrium with a substance or solution to the vapor pressure of pure water.

Water diffuses from regions of high water concentration (low solute concentration) to regions of lower water concentration (higher solute concentration) in the process of osmosis. The cytoplasm of a cell typically has a higher solute concentration than the environment, so the tendency for water is to diffuse into the cell. Under such conditions, the cell is said to be in ***positive water* *balance***, which is the normal state of the cell. However, when acell finds itself in an environment where the solute concentrationexceeds that of the cytoplasm, water will flow out of the cell. If acell has no strategy to counteract this, it will become dehydratedand unable to grow.

**Halophiles-**

Seawater contains about 3% NaCl plus small amounts of many other minerals and elements. Microorganisms that inhabit marine environments almost always have a NaCl requirement and typically grow optimally at the water activity of seawater. Such organisms are called halophiles.

Although halophiles require at least some NaCl for growth, the NaCl optimum observed varies with the organism and is habitat dependent. For example, marine microorganisms typically grow best with 1–4% NaCl, organisms from hypersaline environments (environments that are more salty than seawater), 3–12%, and organisms from extremely hypersaline environments require even higher levels of NaCl. In addition, the requirement for NaCl by halophiles is absolute and cannot be replaced by other salts, such as potassium chloride (KCl), calcium chloride (CaCl2), or magnesium chloride (MgCl2).

**Halotolerant**-

In contrast to halophiles, **halotolerant** organisms can tolerate some level of dissolved solutes but grow best in the absence of the added solute (Figure 5.26).

Halophiles capable of growth in very salty environments are called **extreme halophiles**. These organisms require very high levels of NaCl, typically 15–30%, for optimum growth and are often unable to grow at all at NaCl concentrations below this.

**Osmophiles** –

Organisms able to live in environments high in sugar are called **osmophiles** and those able to

grow in very dry environments (made dry by lack of water rather than from dissolved solutes) are called **xerophiles**.

**Compatible solutes-**

When an organism is transferred from a medium of high *a*w to one of low *a*w, it maintains positive water balance by increasing its internal solute concentration. This is possible by either pumping solutes into the cell from the environment or by synthesizing a cytoplasmic solute. In either case, the solute must not inhibit cellular processes in any significant way. Such compounds are called **compatible solutes**, and are typically highly water-soluble organic molecules including sugars, alcohols, or amino acid derivative. Glycine betaine, a highly soluble analog of the amino acid glycine, is widely distributed among halophilic bacteria. Other common compatible solutes include sugars such as sucrose and trehalose, dimethylsulfoniopropionate, produced by marine algae, and glycerol, a common solute in xerophilic fungi, organisms that grow at the lowest water activities known. In contrast to these organic solutes, the compatible solute of extremely halophilic *Archaea*, such as *Halobacterium*, and a few extremely halophilic *Bacteria*, is KCl.