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# Desalination of Brackish and Marine Waters

The existence of a huge, spreading oil slick in the Persian Gulf raised concern about potable water supplies for Saudi Arabia and other Gulf states. These countries obtain most of their drinking water from desalination. The oil slick may cause moderate curtailment of water supplies, but the inconvenience will not be much greater than that experienced in some California cities during the region's drought. Below is a discussion based on a sampling of the extensive literature on desalination.

About 60% of the world's desalination capacity (or about 2 billion gallons per day) is located on the Arabian Peninsula. Potable water is produced by many plants, and per capita supplies are comparable to those consumed by urban dwellers in the United States. The principal process employed is multi-stage flash (MSF) distillation. An important second-ranking process is reverse osmosis (RO). In most instances MSF is operated in conjunction with thermal electric power plants. Energy liberated by combustion of hydrocarbons is used to make high-temperature, high-pressure steam which in turn drives turbines. Condensate at about 120°C and 3 bars constitutes the energy input into the MSF plant. There, saltwater is distilled in stages at successively lower temperatures and lower gas-phase pressures. Condensing steam from a higher level stage provides heat for the next lower stage. The net output of water is 6 to 20 times that which would be obtained from a single distillation step.

In practice there are problems of corrosion and fouling. These are minimized by treating the seawater before it enters the MSF. The pretreatment includes a filtration process designed to remove inorganic and organic suspended matter. Intakes for the raw seawater are located several meters below the surface of the sea. At that depth, if shielded from an aging oil slick, the amounts of dissolved hydrocarbons present are likely to be on the order of parts per billion. This was the experience in Prince William Sound, and elsewhere. Crude oils contain thousands of compounds and differ mainly in relative proportions of the various constituents. All have low-boiling fractions that quickly evaporate. Other fractions are quite insoluble in water or are nonvolatile. The principal components of concern are the polycyclic aromatic hydrocarbons naphthalene and phenanthrene, which are more soluble than straight-chain hydrocarbons of similar molecular weight. However, the amounts of hydrocarbons in the MSF feed after preliminary treatment of the raw seawater would be tiny, and their boiling points are high. Thus contamination of the product water should be minimal.

Saudi Arabia is not completely dependent on desalination of seawater for its supplies. Wells are present on the land surface. Some of these have brackish water that is not potable. This deficiency has been ameliorated by installation of RO plants. In this process, water under high pressure is forced through membranes, leaving behind most of the content of inorganics and organics and all large entities such as viruses. In Saudi Arabia, the DuPont Company alone has provided membranes for 22 RO brackish water plants having a total capacity of 230 million gallons of water per day. Dow Chemical is also active in production of RO membranes. A recent press release from Dow tells of supplying its products to the U.S. Army. The membranes are now an integral part of the Army's mobile purification units, which supply virtually all of the drinking water for U.S. troops in Saudi Arabia.

The total costs of producing potable water from seawater are on the order of $4 per 1000 gallons. Reclamation of moderately polluted water by RO costs on the order of 50 cents per 1000 gallons. To a thirsty person the $4 number would present no barrier. However, the numbers would be dismaying to a farmer. The energy required for RO is about half or less than that required for MSF. The theoretical requirement for RO is 3 kilowatt-hours per 1000 gallons. In practice, 15 to 30 kilowatt-hours are required. Other major costs arise from amortization of capital and the processing of feed waters to minimize fouling of membranes.

Use of desalting equipment is not confined to the Arabian Peninsula. Worldwide, nearly 4000 plants are involved in scores of countries producing a total of about 3.4 billion gallons of potable water per day.

In advanced temperate countries having adequate rainfall, RO is destined to have a major future role in such applications as treatment of municipal wastes, agricultural runoff, textile wastes, and wastes of industries using large quantities of water. RO is also useful as a step in preparing highly purified water. It can serve to reduce the level of salts and organic substances to low levels as a preliminary to final purification by ion-exchange resins.

—PHILIP H. ABELSON