AEROBIC vs ANAEROBIC METABOLISM

AEROBIC: ORGANICS + O_2 → CO_2 + H_2O + ENERGY

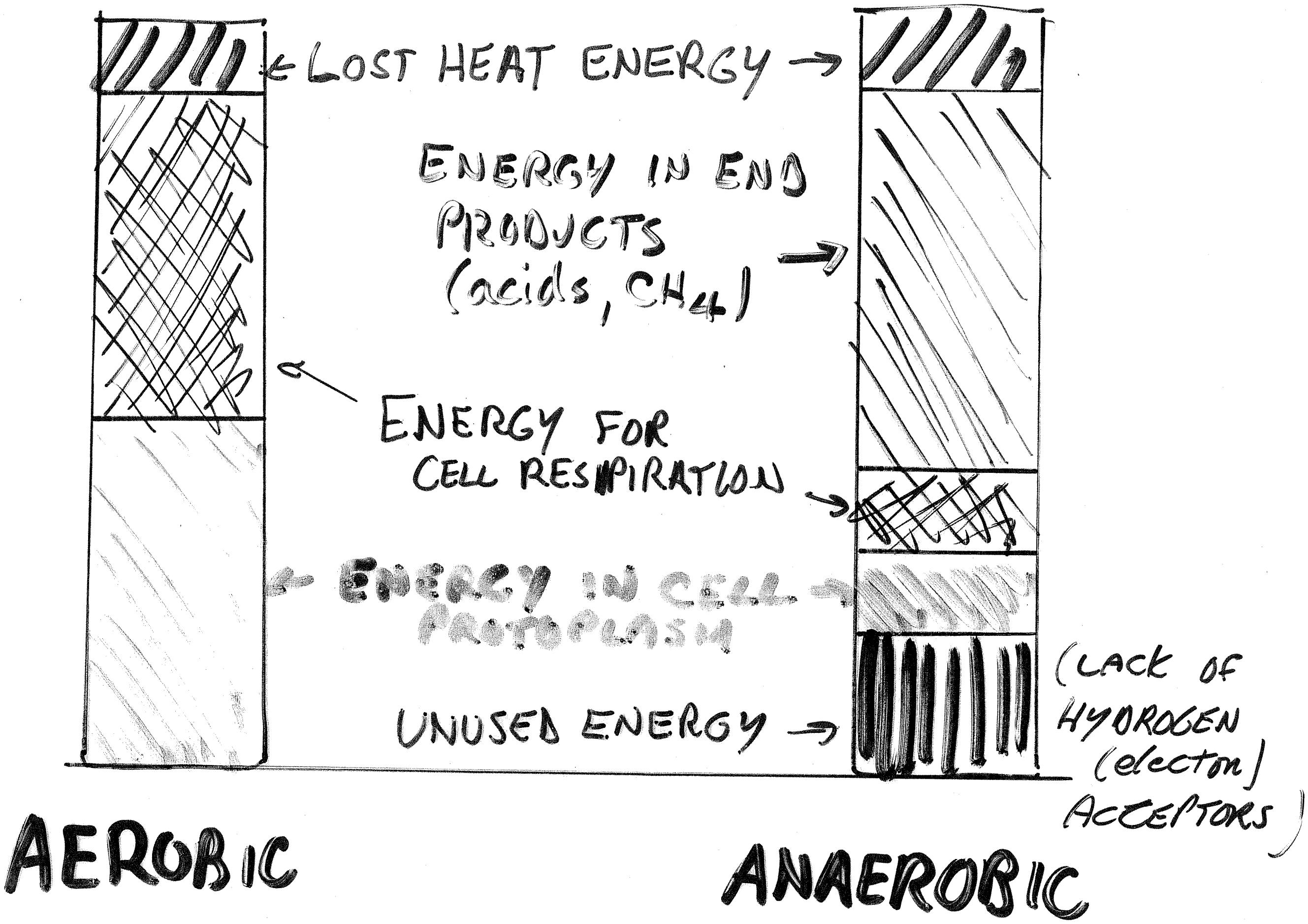
ANAEROBIC: ORGANICS → (ACID) INTERMEDIATES + CO_2 + H_2O + ENERGY

ORGANIC-ACID INTERMEDIATES → CH_4 (METHANE) + CO_2 + ENERGY

AEROBIC:
- Maximum Energy to bugs and
- significant CELL GROWTH possible

ANAEROBIC:
- Much less metabolic energy available to bugs
- More energy in by-products (CH_4)
- Less cell mass produced

COMPARISON OF ENERGY CONVERSIONS: AEROBIC vs. ANEAROBIC



- Ultimately, Volatile-Solids reduction is about the same for both (AEROBIC: Cells destroyed endogenously)

- MAJOR DIFFERENCES:
  - Characteristics of product.
  - Valuable by-product of anaerobic (methane)

PRO'S & CON'S:

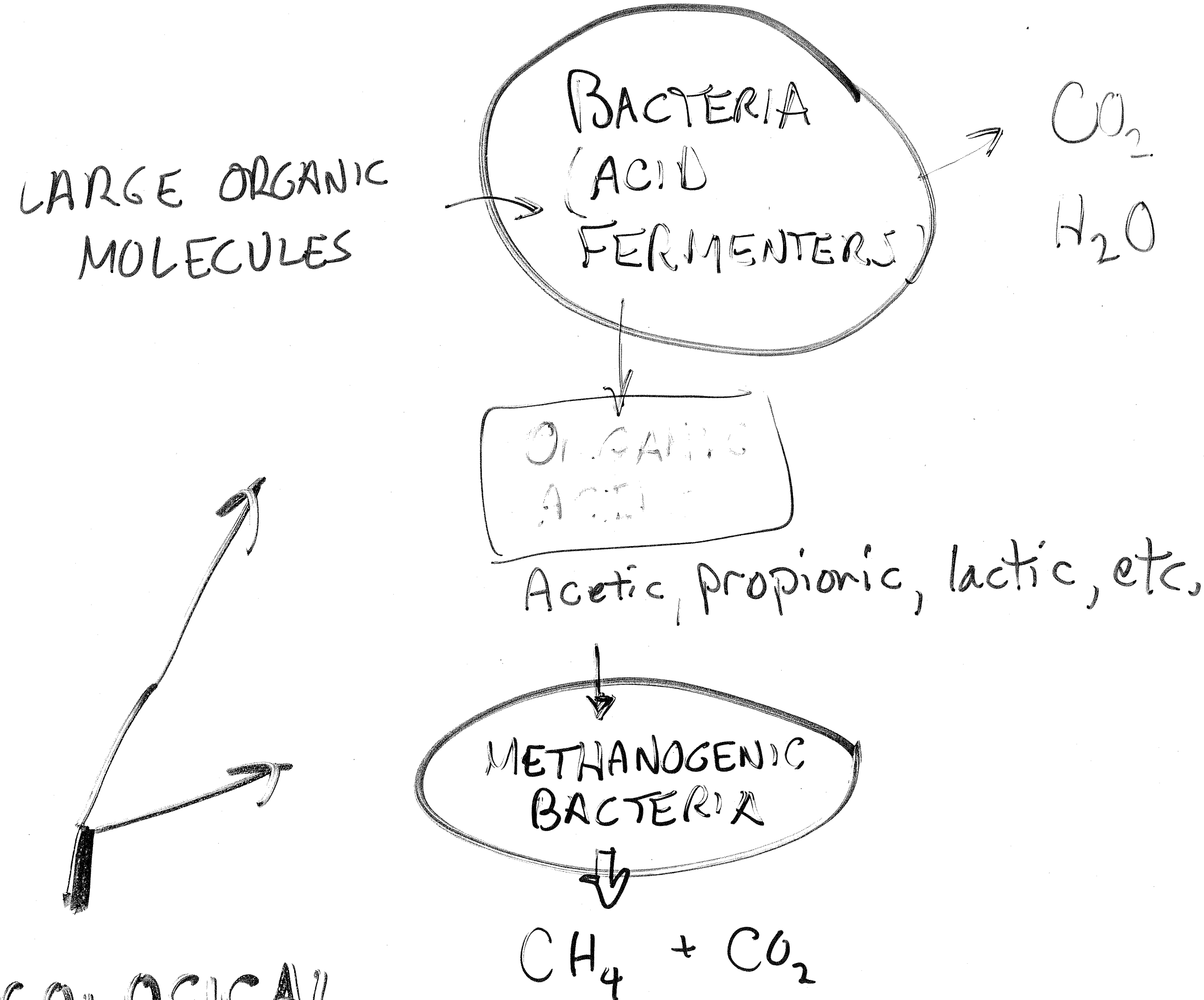
AEROBIC

LOWER BOD IN SUPERNATANT	HIGH POWER COST FOR AERATION
ODORLESS, HUMUS-LIKE STABLE ENDPRODUCT	DIGESTED SLUDGE HAS POOR DEWATERING CHAR'S
BETTER SOIL AMENDMENT	PROCESS SENSITIVE TO TEMP (EXTERNAL CONDITIONS)
EASIER OPERATION	NO USEFUL BY-PRODUCTS (other than sludge itself)
LOWER CAPITAL COSTS	
(BEST FOR SMALL PLANTS)	

ANAEROBIC

VERY USEFUL BY-PRODUCT (~ 65% methane gas)	MAY REQUIRE HEATING
NO AERATION COSTS OR EQUIPMENT	OPERATION COMPLEX & REQUIRES CLOSE MONITORING
SLUDGE: GOOD DEWATERING	DIGESTOR CAN QUICKLY GET OUT OF BIOL. BALANCE
LARGELY ISOLATED FROM EXTERNAL CONDITIONS	HIGHER (SOLUBLE) BOD IN SUPERNATANT
(BEST FOR LARGE PLANTS)	ENDPRODUCT MAY HAVE SOME ODOR, REQUIRE COMPOSTING FOR LAND APPLICATION

ANAEROBIC SLUDGE DIGESTION



ECOLOGICAL CONSORTIUM

Health of Ecosystem:

- **Drop in gas (CH_4) prod'n**
- **Rise in acids (lower pH)**
- **More CO_2 less CH_4**

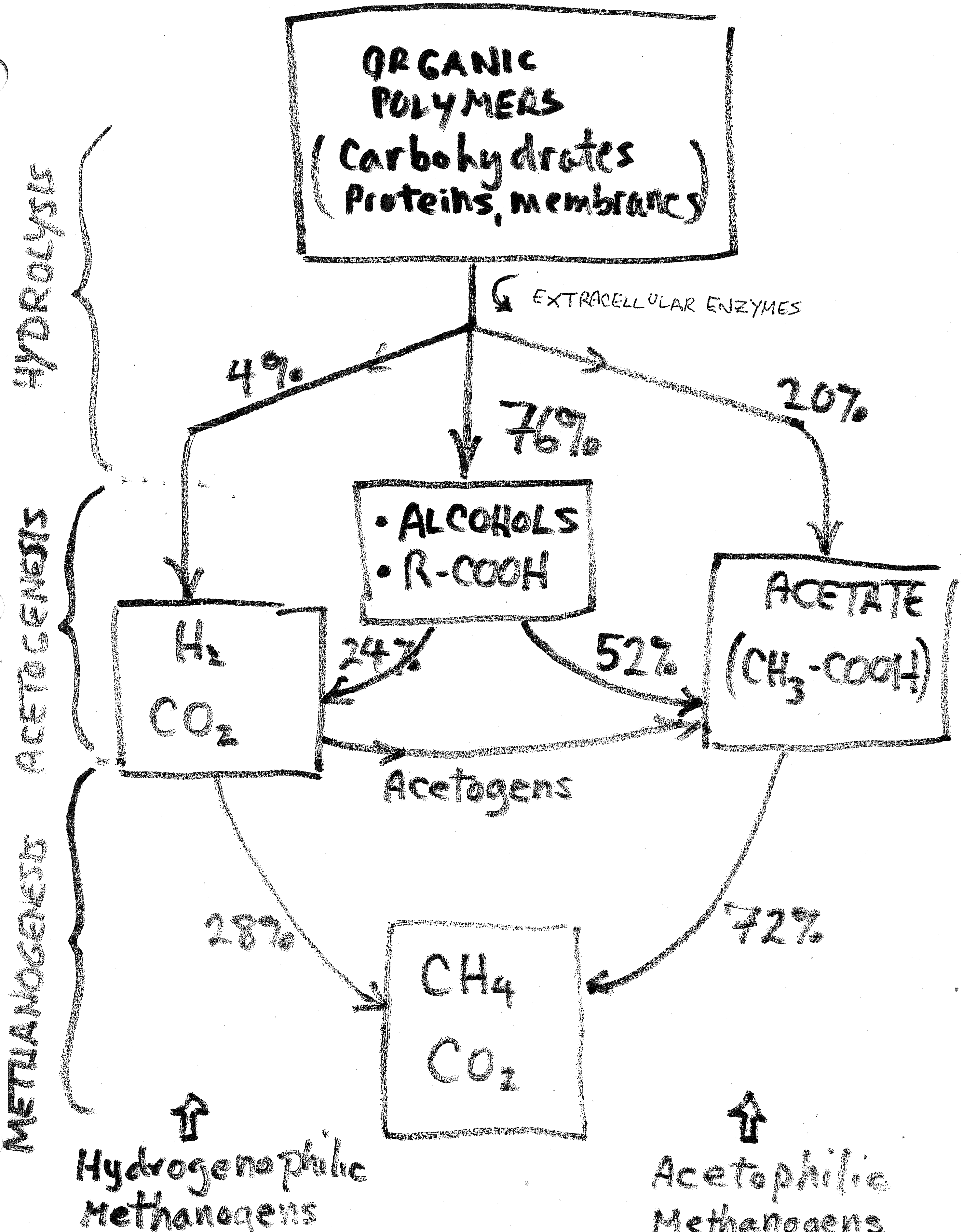

ORGANIC POLYMERS (Carbohydrates Proteins, membranes)
EXTRACELLULAR ENZYMES
4%
76%
20%
• ALCOHOLS • R-COOH
H_2 CO_2
ACETATE (CH_3-COOH)
24%
52%
Acetogens
28%
72%
CH_4 CO_2
HYDROLYSIS
ACETOGENESIS
METHANOGENESIS
Hydrogenophilic Methanogens
Acetophilic Methanogens

TABLE 13.7 General Conditions for Sludge Digestion

Temperature	
Optimum	98°F (37°C)
General range of operation	85°–95°F (29°–35°C)
pH	
Optimum	7.0–7.1
General limits	6.7–7.4
Gas production	
Per pound of volatile solids added	8–12 ft^3 (230–340 l)
Per pound of volatile solids destroyed	16–18 ft^3 (450–510 l)
Gas composition	
Methane	65%–69%
Carbon dioxide	31%–35%
Hydrogen sulfide	Trace
Volatile acids concentration as acetic acid	
Normal operation	200–800 mg/l
Maximum	Approx. 2000 mg/l
Alkalinity concentrations as $CaCO_3$	
Normal operation	2000–3500 mg/l
Minimum solids retention times	
Single-stage digestion	25 d
High-rate digestion	15 d
Volatile solids reduction	
Single-stage digestion	50%–70%
High-rate digestion	50%

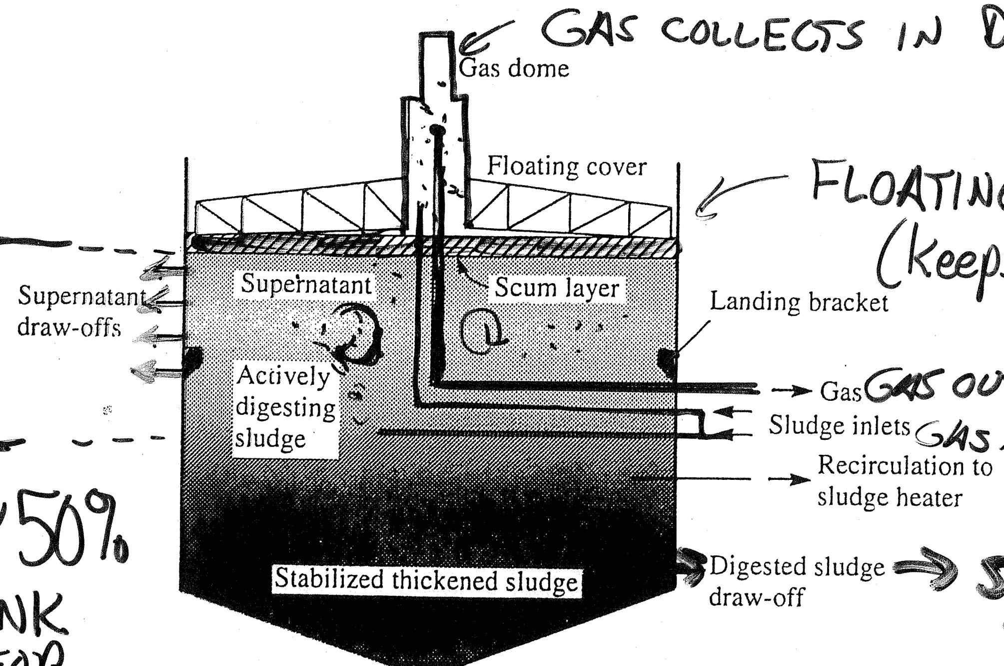


Figure 13.11 Cross-sectional diagram of a floating-cover anaerobic digester.

∴ ALONE: Principally small operations

sludge, moves along the ceiling of the cover, and collects in the gas dome. The cover can float on the surface of the sludge between the landing brackets and the height of the overflow pipe. Rollers around the circumference of the cover keep it from binding against the tank wall.

Often Remove sludge in batches

Three functions of a single-stage floating-cover digester are (1) anaerobic digestion of the volatile solids, (2) gravity thickening, and (3) storage of the digested sludge. A floating-cover feature of the tank provides for a storage volume equal to approximately one-third that of the tank. The unmixed operation of the tank permits gravity thickening of sludge solids and withdrawal of the separated supernatant. Anaerobic digestion of the sludge solids is promoted by maintaining near optimum temperature and stirring the digesting sludge through the recirculation of heated sludge. However, the rate of biological activity is inhibited by the lack of mixing; on the other hand, good mixing would prevent supernatant formation. Therefore, in single-tank operation, the biological process is compromised to allow both digestion and thickening to occur in the same tank.

In the operation of an unmixed digester, raw sludge is pumped to the digester from the bottom of the settling tanks once or twice a day. Supernatant is withdrawn daily and returned to the influent of the treatment plant. It is normally returned by gravity flow to the wet well during periods of low raw-wastewater flow, or, in the case of an activated-sludge plant, it may be pumped to the head end of the aeration basin. Because of the floating cover, supernatant does not have to be drawn off simultaneously with the pumping of raw sludge into the digester.

Digested sludge is stored in the tank and withdrawn periodically for disposal. Spreading of liquid sludge from smaller plants on grassland or cropland is common practice in agricultural regions. In larger plants, it is mechanically dewatered and used mixing of the digesting sludge either mechanically or by use of compressed digestion gases. Mechanical mixing is normally accomplished by an impeller suspended from the cover of the digester [Fig. 13.12(a)]. Three common methods of gas mixing are the injection of compressed gas through a series of small-diameter pipes hanging from the cover into the digesting sludge [Fig. 13.12(b)]; the use of a draft tube in the center of the tank, with compressed gas injected into the tube to lift recirculating sludge from the bottom and spill it out on top [Fig. 13.12(c)]; and supplying compressed gas to a number of diffusers mounted in the center at the bottom of the tank [Fig. 13.12(d)].

A completely mixed digester may be either a fixed- or a floating-cover tank. Digesting sludge is displaced when raw sludge is pumped into a fixed-cover digester. By use of a floating cover, tank volume is available for the storage of digesting sludge, and withdrawals do not have to coincide with the introduction of raw sludge.

The homogeneous nature of the digesting sludge in a high-rate digester does not permit formation of supernatant. Therefore, thickening cannot be performed in a completely mixed digester. High-rate digestion systems normally consist of two tanks oper-

HIGH-RATE (WELL MIXED)