CHAPTER 5

AEROBIC DIGESTION

Growth of Activated Sludge Organisms

When activated sludge purifies sewage in the presence of dissolved oxygen, the bacterial cells grow in size until each cell divides into two daughter cells. The process continues until:

a The food supply is exhausted (i.e. when the sewage is completely purified), or

b Other factors limit the growth, e.g. lack of nutrients, deficiency of dissolved oxygen, and build-up of toxic end-products.

Normally, something like 60 per cent of the organic matter in sewage, as measured by the 5-day B.O.D. test, is assimilated to form new sludge cells.

A typical growth curve of activated sludge organisms is shown in Figure 6 .

The growth curve can be divided into the following phases.

(1) Lag phase - At the beginning, there is sometimes a lag phase of slow growth of cells. This does not normally occur in the treatment of sewage by activated sludge as the organisms would be in an active state. If only occurs when adaptation of the bacteria to a new waste is taking place and so may happen with many trade wastes unless acclimatised seed material is used.

(2) Logarithmic growth phase (or log phase) - This is a phase of increasing growthto constant growth. A more rapid

rate of cell growth occurs here and the rate of cell multiplication is at a maximum because the

$$\frac{\text{Food}}{\text{Cell}} \text{ ratio } \doteq \frac{\text{kg (lb) of B.O.D.}}{\text{kg (lb) of aeration solids}} \text{ is high.}$$

In the conventional activated sludge process, the maximum rate of removal of B.O.D. takes place at this stage. Moreover, since the sludge increases in quantity on account of the very rapid growth of micro-organisms, surplus sludge not required in the process must be regularly removed.

(3) Declining growth phase Growth of cells starts to decline here as the food supply diminishes with breakdown and purification of the sewage. The growth curve reaches its maximum here. The food: cell ratio is low and is decreasing. The rate of removal of B.O.D. decreases as the organic matter is consumed.

(4) Endogenous respiration (or maximum stationary) phase - The growth curve falls rapidly here as the organic matter becomes exhausted. The insufficient food supply oompels the organisms to utilise organic matter within the cell. This is so-called 'endogenous respiration' since dissolved oxygen is still required for this phase. It is really a process of auto-digestion or 'aerobic digestion'. It only occurs to a limited extent in the conventional activated sludge process. But, it predominates in, and is a characteristic feature of, the extended aeration process.

After this phase, growth ceases owing to the death of the organisms due to exhaustion of nutrients and to production of metabolic poisons.

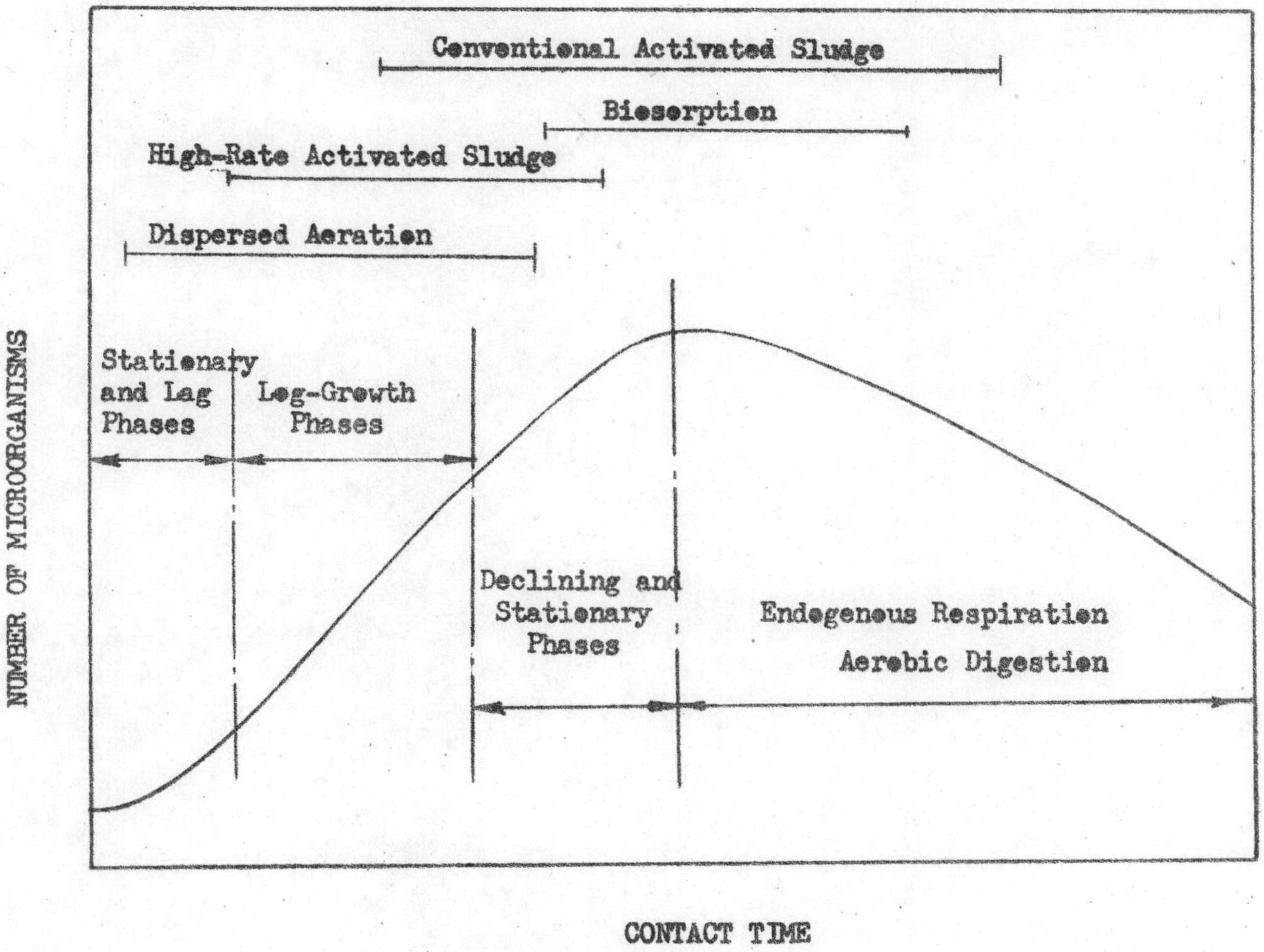

FIG.6 TYPICAL GROWTH CURVE FOR ACTIVATED SLUDGE (Eckenfelder, 1956)

Aerobic digestion is the newest method for treating waste activated sludge.

Basic Theory of Aerobic Digestion

The growth phase during which cells use their own cell material and surrounding dead cells for food is termed the endogenous respiration phase. It occurs when the nutrient level in the environment is insufficient to support the living biological mass. Some of the cell material is non-biodegradable or is utilized at a negligible rate during the detention times used in aerobic digestion. Some non-biodegradable materials are hemicellulose and cellulose employed in the cell walls. During a period of several months this material will be degraded, but in the design of aerobic digestion units the rate of decomposition is negligible. Hence, a portion of the cell material will be termed non-biodegradable.

The rate of endogenous decay is represented by the first order biochemical equation,

$$\frac{dS}{dt} = - K_d S \qquad (1)$$

dS = change in biodegradable cell material

dt = time interval

K_d = rate of decay constant

S = concentration of biodegradable cell material at time, t.

Equation (1) may be rearranged for integration between definite limits as follows,

$$\int_{S_o}^{S_t} \frac{dS}{S} = - K_d \int_{o}^{t} dt. \qquad (2)$$

Integration gives,

$$\ln S \Big]_{S_o}^{S_t} = - K_d t \qquad (3)$$

which after substitution gives,

$$\ln \frac{S_t}{S_o} = - K_d t. \qquad (4)$$

This equation may be rearranged to give,

$$\frac{S_t}{S_o} = e^{-K_d t} \qquad (5)$$

Equation (4) will plot a straight line when plotted on semilog paper. The y - axis is then $\frac{S_t}{S_o}$ values and the x-axis is the values of t. The slope of the line would be $\frac{K_d}{2.303}$ (Reynolds, 1967)