CHAPTER 4

Equalization and Proportioning

Equalization

Industry will always realize benefits from delivering a constant quantity and quality of waste from its plant. It will further benefit from delivering this waste in proportion to that occurring in its discharge environment—be it river or sewer line. The reason for these facts is that receiving environments can always cope better with a constant load of contaminant and in proportion to its own existing load. In fact, an industrial plant can sometimes forgo any further expensive treatment of its wastes after equalization and proportionment.

Equalization is a method of retaining waste in a basin so that the effluent discharged is fairly uniform in its water quality characteristics (pH, color, turbidity, alkalinity, biochemical oxygen demand [BOD], and so forth). A secondary but significant effect is that of lowering the concentration of effluent contaminants. This is accomplished not only by ironing out the slugs of a high concentration of contaminants but also by physical, chemical, and biological reactions that may occur during retention in equalization basins. For example, the increases in industrial waste reported by Fall (1965) at Peoria have greatly varied the organic loading at the treatment plant. A retention pond serves to level out the effects of peak loadings on the plant while substantially lowering the BOD and suspended-solids load to the aeration unit. Air is sometimes injected into these basins to provide: (1) better mixing; (2) chemical oxidation of reduced compounds; (3) some degree of biological oxidation; and (4) agitation to prevent suspended solids from settling.

The size and shape of the basins vary with the quantity of waste and the pattern of its discharge from the factory. Most basins are rectangular or square, although Metzger (1967) found that triangular tanks produce satisfactory flow distribution. The capacity should be adequate to hold, and render homogeneous, all the waste from the plant. Almost all industrial plants operate on a cycle basis; thus, if the cycle of operations is repeated every 2 hours, an equalization tank that can hold a 2-hour flow will usually be sufficient. If the cycle is repeated only every 24 hours, the equalization basin must be big enough to hold a 24-hour flow of waste. Herion and Roughhead (1964) reported the use of 72-hour equalization for a pharmaceutical waste to ensure ample mixing. This period (three times the 24-hour cycle of operations) was selected as the proper detention time to

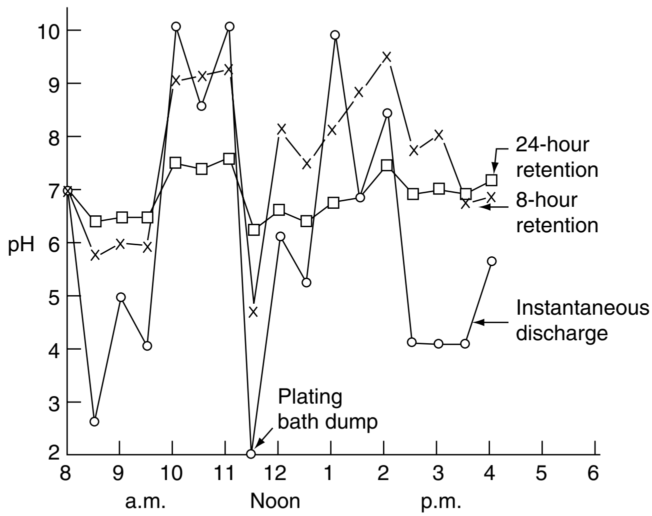

FIGURE 4.1. Effect of equalization.

not disrupt the biota of the activated-sludge units. In a wool-finishing-mill waste containing dieldrin (a mothproofing insecticide), an equalization period of 44 days was necessary to yield a receiving stream concentration of less than 0.0005 mg/liter. Figure 4.1 compares the effects of 8-hour and 24-hour detention periods on the final pH of metal-plating waste.

The mere holding of waste, however, is not sufficient to equalize it. Each unit volume of waste discharged must be adequately mixed with other unit volumes of waste discharged many hours previously. This mixing may be brought about in the following ways: (1) proper distribution and baffling; (2) mechanical agitation; (3) aeration; and (4) combinations of all three.

Proper distribution and baffling is the most economical, though usually the least efficient, method of mixing. Still, this method may suffice for many plants. Horizontal distribution of the waste is achieved by using either several inlet pipes, spaced at regular intervals across the width of the tank, or a perforated pipe across the entire width. Over-and-under baffles are advisable when the tank is wide because they provide more efficient horizontal and vertical distribution (Figure 4.2). Baffling is especially

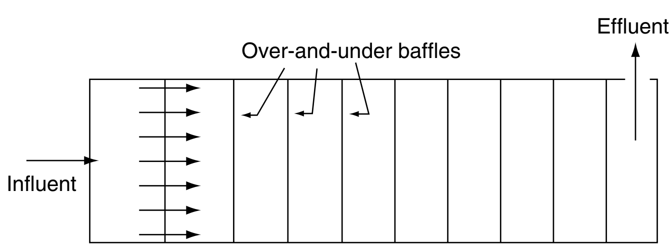

FIGURE 4.2. Top view of an equalizing basin, with perforated inlet pipe and over-and-under baffles.

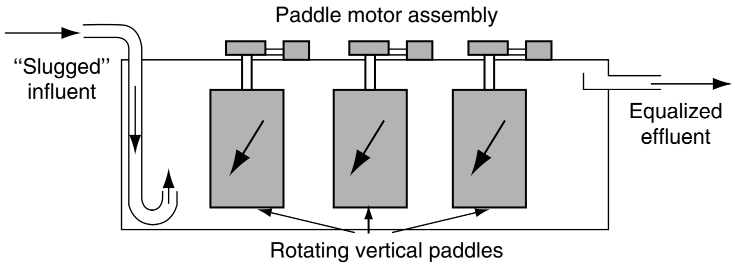

FIGURE 4.3. Side view of an equalizing basin, with mechanical agitators instead of baffles.

important when several types of waste enter the basin at various locations across the width. The influent should be forced to the bottom of the basin so that the entrance velocity prevents suspended particles from sinking and remaining on the bottom.

Mechanical agitation eliminates most of the need for baffles and generally provides better mixing than baffles alone. One typical arrangement (Rudolfs and Millar 1946), shown in Figure 4.3, uses three wooden gate–type agitators spaced equidistantly along the center line of the length of the tank. Agitators operated at a speed of 15 rotations/min (rpm) by a 3-horsepower (hp) motor are usually adequate.

The design in Figure 4.3 approximates the theoretically ideal tank, because of its relatively high efficiency at similar detention times, as a result of mechanical mixing, and because it prepares various types of chemical waste for direct disposal or final treatment. If subsequent treatment is necessary, the process is made easier because the problem of waste with rapidly changing characteristics varying from one extreme to the other is eliminated. Rudolfs and Millar (1946) recommended this method of equalization when: (1) limited space is available; (2) removal of suspended solids is not desired; (3) there are rapid fluctuations in the characteristics of the waste; and (4) facility of subsequent treatment is a goal.

This type of equipment is good not only for equalization but also for dilution, oxidation, reduction, or any other function in which one wants chemical compounds discharged to react with compounds discharged before or after them, to produce a desired effect.

Aeration of equalizing basins is the most efficient way to mix types of waste, but it is also the most expensive. To aerate an equalizing basin takes about half a cubic foot of air per gallon of waste. Aeration facilitates mixing and equalization of waste, prevents or decreases accumulation of settled material in the tank, and provides preliminary chemical oxidation of reduced compounds, such as sulfur compounds. It is of special benefit in situations in which wastes have varying character and quantity, excess of reduced compounds, and some settleable suspended solids.

Proportioning

Proportioning means the discharge of industrial wastes in proportion to the flow of municipal sewage in the sewers or to the stream flow in the receiving river. In most cases, it is possible to combine equalization and proportioning in the same basin. The effluent from the equalization basin is metered into the sewer or stream according to a predetermined schedule. The objective of proportioning in sewers is to keep constant the percentage of industrial wastes to domestic sewage flow entering the municipal sewage plant. This procedure has several purposes: (1) to protect municipal sewage treatment using chemicals from being impaired by a sudden overdose of chemicals contained in the industrial waste; (2) to protect biological-treatment devices from shock loads of industrial wastes that may inactivate the bacteria; and (3) to minimize fluctuations of sanitary standards in the treated effluent.

The rate of flow of industrial waste varies from instant to instant, as does the flow of domestic sewage, and both empty into the same sewage system. Therefore, the industrial waste must be equalized and retained, and then proportioned to the sewer or stream according to the volume of domestic sewage or stream flow. To facilitate proportioning, a holding tank should be constructed with a variable-speed pump to control the effluent discharge. Because the domestic sewage treatment plant is usually located some distance from an industry, signaling the time and amount of flow is difficult and sometimes quite expensive. For this reason, many industries have separate pipelines through which they pump their wastes to the municipal treatment plant. The wastes are equalized separately at the site of the municipal plant and proportioned to the flow of incoming municipal wastewater. Separate lines are not, of course, always possible or even necessary. One textile mill found that it could effectively proportion its waste to the variable domestic sewage flow by adjusting the valve on the holding-tank effluent pump at 8:00 A.M., 12:00 noon, and 7:00 P.M.

There are two general methods of discharging industrial waste in proportion to the flow of domestic sewage at the municipal plant: manual control related to a well-defined domestic sewage flow pattern, and automatic control by electronics.

Manual control is lower in initial cost but less accurate. It involves determining the flow pattern of domestic sewage for each day of the week over a period of months. Usually one does this by examining the flow records of the sewage plant or by studying the hourly water-consumption figures for the city. It is better to spend time on a careful investigation of the actual sewage flow than to make predictions based on miscellaneous nonpertinent records. Actual investigative data should be used to support those records that are applicable to the case.

Automatic control of waste discharge according to sewage flow involves placing a metering device that registers the amount of flow at the most convenient main sewer connection. This device translates the rate of flow in the sewer to a recorder located near the plant's holding tank. The pen on the recorder actuates either a mechanical (gear) or a pneumatic (air) control system for opening or closing the diaphragm of the pump. There are, of course, many variations of automatic flow-control systems. Although their initial cost is higher than that of manual control, they will usually return the investment many times by the savings in labor costs.

Some industrial and municipal sewage plant superintendents think that the best time to release a high proportion of industrial waste to the sewer is at night, when the domestic sewage flow is low. Whether night release is a good idea depends on the type of treatment used and the character of the industrial waste. If the treatment is primarily biological and the industrial wastes contain readily decomposable organic matter and no toxic elements, discharging the largest part of the industrial waste to the treatment plant at night is indeed advisable, because this ensures a relatively constant organic load delivered to the plant day and night.

One equipment manufacturing company recommends a three-component system for automatic proportioning of wastes into sewers (Figure 4.4): (1) a kinematic manometer with integral pneumatic transmitter; (2) a remotely located indicator program controller, which receives air signals and has a precut time pattern cam for continuously adjusting the set point of the pneumatic controller to give a waste-flow rate in accordance with the desired pattern; and (3) a diaphragm-actuated, motor-controlled valve that is actuated by the air signal from the program controller. Practically speaking, the length of the pneumatic capillary tubing limits the physical separation between the sensing components, but this difficulty can be overcome with an electrical system.

The typical waste-flow proportioning system (Bubbler System) shown in Figure 4.4, as supplied by Fischer and Porter Co., consists essentially of the three separate devices described in the previously. Item 1 (Figure 4.4), with a linear air-pressure output of 3–15 pounds/in^2, has a flow range of 17–170 gallons/min of an industrial waste (specific gravity assumed, 1.1). Item 2 (Figure 4.4) is a remotely located indicator for receiving air signals from Item 1, as explained in the text. Item 3 (Figure 4.4) is an automatic valve capable of operating at a maximum pressure drop of 10 pounds at maximum flow rate. This valve is actuated by air signals from the program controller, Item 2 (Figure 4.4).

Another arrangement for proportioning industrial wastes in a situation in which pipelines are flowing only partly full or waste flows in open channels, is the use of a weir, flume, or Kennison nozzle in the main flow line to measure the flow. A float-operated transmitter (either electrical or pneumatic) is connected to this measuring device and the electrical or pneumatic signals are used to actuate a flow splitter in a proportioning weir tank (such as is provided by Proportioneers, Inc.).

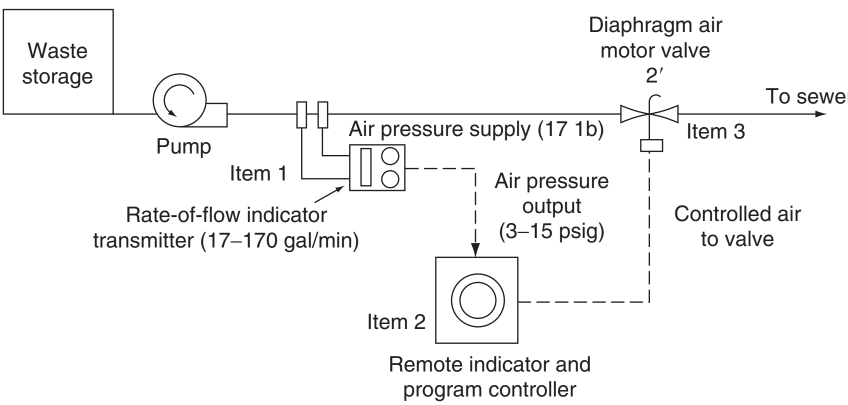

FIGURE 4.4. Waste-metering system (courtesy Fischer and Porter Company).

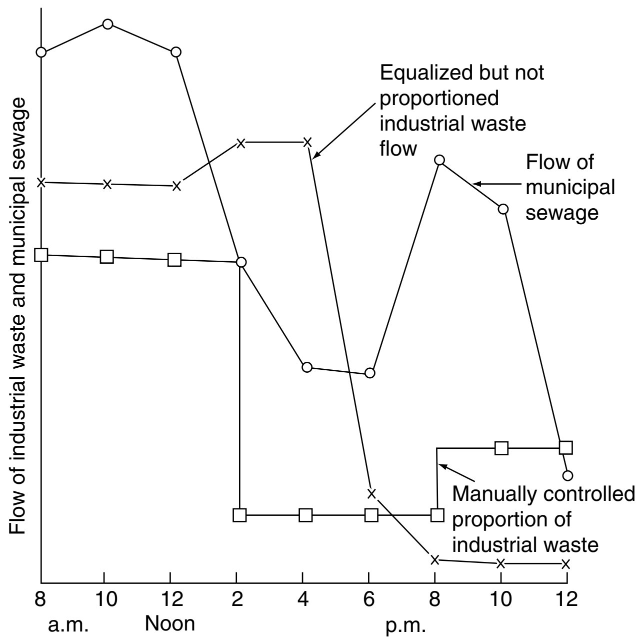

FIGURE 4.5. Effect of proportioning.

The Belle, West Virginia, works of the DuPont Nemours Company has been impounding its waste in two 2.5-million-gallon tanks and releasing it to the Kanawha River in proportion to the river flow for more than 10 years (Hyde 1965). This has been necessary owning to the flashiness of the river flows. Figure 4.5 compares the effects of both equalization and proportioning on the flow at a municipal treatment plant.

By equalizing a tannery mill waste while aerating it for 24 hours and proportioning the effluent for further treatment, it was possible to obtain high BOD removals previously found unattainable (Nemerow et al. 1978).

Example of Twentieth-Century Practice of Equalization and Proportioning

Crumb and West (2000) proposed a better and more cost-effective way to meet permit requirements during wet weather. Their pilot plant results show that removal efficiency of all processes were considerably better than conventional clarification. Using an enhanced high-rate clarification (EHRC) process, Crumb and West (2000) showed that treatment of peak wet weather flow produced effluent suitable for discharge into the Trinity River. In their presentation, Crumb and West (2000) provide a schematic diagram of the blending of storm flow with domestic wastewater to yield efficient removal of contaminants, thus using a modification of the equalization and proportioning process.

Review Questions

1. Define *equalization,* including its purpose.
2. What are four methods of mixing to effect equalization?
3. What are the objectives of proportioning of industrial wastes?
4. What are the problems associated with proportioning industrial wastes into municipal sewers?

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