CHEMISTRY OF SEWAGE PURIFICATION.*

By Dr. Arthur Lederer.†

Sewage may be purified in part either by mechanical, chemical, or biological means, in combination or separately. Thorough knowledge of all the agencies at work in the biological purification of sewage has not been attained. The clarification of sewage by chemicals is easily explained by the reaction taking place, and the mechanical action of the floc formed. Since biological treatment is very largely used, more time will be devoted to that general process.

Unless specifically stated to the contrary, the remarks in this paper refer to dilute domestic sewage, and not to trade wastes. The treatment of sewages containing trade wastes, or of trade wastes themselves, is a problem in itself, requiring many different processes. The chemistry of the purification of trade wastes depends largely on the character of the wastes. As a rule, such wastes do not interfere with the common methods of disposal, unless they are present in in excessive quantities, or are poisonous, either to men, animals, or fish.

Physical Characteristics.—The physical characteristics of weak domestic sewage, from a large sewerage area as represented by the area draining to the 39th Street testing station, in Chicago, are subject to variations, depending, in part, on the rain-fall or snow-fall. In dry weather the sewage appears turbid, with a yellowish cast from the urine and feces; a perceptible quantity of settling suspended matter is present, in color ordinarily light gray, changing to dark gray, or even black in the storm-water sewage. The odor of the fresh sewage is slightly gaseous, but not at all repugnant as might be supposed. Other sewages might show different physical characteristics, depending upon the water consumption and other factors. As a rule, American sewages are far more dilute than foreign sewage, because of the great waste of water in the United States. A European sewage may, therefore, have not only a more repugnant appearance, but will often possess a strong putrid odor. The development of such an odor depends upon the amount of oxygen in solution.

Changes in Sewage on Decomposition.—The sewage handled at the 39th Street testing station contains some oxygen in solution, as well as nitrites and nitrates, during the greater part of the year, in particular during the winter. Such a sewage is called a fresh sewage. When the oxygen content—the dissolved oxygen as well as the oxygen in the nitrites and nitrates—becomes exhausted, the sewage turns stale, and the organic matter begins to break down, marking the first step toward the ultimate mineralization of the organic putrescible matter,—a change due mainly to the powerful activity of bacteria and enzymes. At this stage the free ammonia gradually increases, combining with the carbon dioxide to form ammonium carbonate. The organic carbon is oxidized as long as free oxygen persists in the sewage. Eventually anaerobic decomposition follows, resulting in the formation of gaseous decomposition products, of which hydrogen sulphide is very prominent. Free nitrogen is likewise released. The sewage becomes septic. The larger the proportion of putrescible matter present, and the smaller the amount of oxygen in solution, the quicker does a sewage become septic. The carbonaceous and nitrogeneous compounds present in the sewage are further attacked by anaerobic micro-organisms,—an action which frequently produces a nuisance.

The term septic has never been strictly defined, but may cover the lack of oxygen in the fluid, and the toxic or septic effect of anaerobic decomposition products upon aerobic organisms. Sometimes reference is made to an over-septic condition, which, to the writer's understanding, is one based upon the inhibition of the growth of anaerobic organisms by their own decomposition products. The term to-day is used vaguely, and requires standardization.

Physical Record.—In our laboratory we record the physical properties, as well as the quantities of settling suspended matter in the sewage, and any peculiarity in color. Sometimes the color becomes distinctly yellowish, a reddish precipitate gradually settling out. In such a sample the alkalinity is found to be low, and the sulphates high. We have traced this to the discharge of pickling liquor wastes from a wire works.

Preservation of Samples.—The odor of samples of sewage, or purified effluents, is not recorded as a routine procedure. The reason is that the samples are collected over 24 hours for crude sewage, and over 48 hours for other effluents. To avoid change in the chemical constituents, a preservative is added,—in our case chloroform to the amount of 10 c.c. to one gallon of sewage. The chloroform effectually hides any odor present, unless hydrogen sulphide occurs in large quantities. As an additional precaution, the samples are kept in cold storage up to the time of analysis.

Exhaustive study into the question of the preservation of sewage samples has shown us that, even in a storage period as short as 6 hours, perceptible changes will occur in the nitrogeneous constituents of a fresh unpreserved sewage. At room temperature, the addition of 10 c.c. of chloroform to one gallon of sewage checks the decomposition to some extent, but even in such cases, immediate analysis is often desirable to obtain accurate results. Cold storage alone is a fair preservative. The combination of chloroform and cold storage is the best obtainable method at present. An ideal preservative is lacking for liquids, like sewage, of changing character. It should be odorless and colorless, and should not affect any of the constituents present or interfere with the analytical determinations.

Suspended Matter.—During the various stages of sewage purification, it is important to observe the physical and quantitative changes in the suspended matter, since the aim to-day is to remove as much as possible at the outset, in order to obtain a fresh effluent. In studying the efficiency of a device, frequent determinations are necessary both for the influent and effluent, extending over a considerable period, before an opinion can justly be formed of the percentage removal of suspended matter.

The settling suspended matter should be clearly distinguished from the non-settling suspended matter, in studying the efficiency of a settling device. Much of the suspended matter in sewage, particularly on large areas, occurs in a finely divided, or colloidal state, not capable of sedimentation even on prolonged storage; hence, when a settling tank is removing perhaps 35% of the total suspended matter, it may actually be taking out 100% of the suspended matter capable of settling. On prolonged storage, however, some of the colloidal matter may coagulate, and material previously in silution will also change to apparent settling matter. This is particularly true for strong sewages. From our analysis of the composition of the settling and non-settling suspended matter, it is evident that the percentage if volatile matter is greater in the non-settling portion. This may have a very important bearing upon the true character of a settled sewage from the standpoint of a prospective nuisance in a stream.

The settled suspended matter is termed sludge. The percentage of volatile and fixed matter depends upon the character of the sludge, a fresh sludge containing more

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† Chemist and Bacteriologist, The Sanitary District of Chicago