Sanitation — Sewage
Chem - Proc - Art.

Chemical-Mechanical Treatment of Sewage

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III—Pretreatment, Flocculation, Precipitation and Filtration

More Uniform Plant Load Pretreatment of sewage will provide a more uniform load on the chemical treatment plant. It is well known that the rate of sewage flow fluctuates hourly, the intensity of the variation being controlled largely by the size of the sewer system. In a relatively small sewer system having a quick run-off, the hourly variation is quite pronounced; whereas in large sewer systems the peak loads from districts or areas are smoothed out by the time required to reach the plant. In addition to the volume, the suspended solids content of the sewage varies hourly, and when variation in both flow and concentration of the sewage are compounded it can readily be seen that the incoming load on the plant is subject to large variations.

As in the activated sludge process, pretreatment serves to remove the variations in the incoming load, and the applied sewage will therefore be more uniform in concentration. Also the removal of a major portion of the settleable solids will reduce the amounts of coagulating chemicals required and will tend to simplify the adjustment of chemical dosage, as the coagulation required is that of the colloidal or pseudo-colloidal solids.

Pretreatment Methods Pretreatment of sewage can be done in a primary or pre-settling tank, or by passing the sewage through what is termed a "coal mat" filter, both of which will serve to remove the major portion of settleable solids. With

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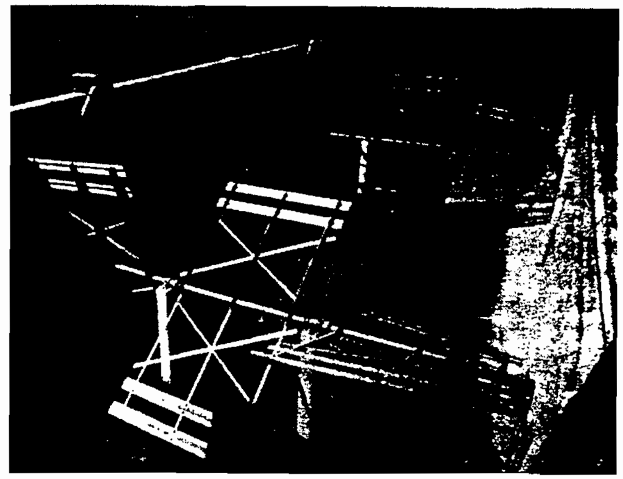

Fig. 3. Dorr flocculators.

pretreatment units, the chemical sludge from the final settling tank can be returned to and mixed with the raw sewage, whereby the thin chemical sludge is mixed with the thicker raw sludge and a more concentrated sludge is obtained for treatment and disposal.

Additions of Inert Materials

Application Questonable Various attempts have been made to improve flocculation and precipitation of the solids by adding inert material to the sewage, the theory being an increased crystal density and improved flocculation. There is nothing particularly new in this, as it was tried frequently in the old order of chemical treatment and consisted of the addition of clays, charcoal, ground charred bone, paper pulp and various fibrous materials. Numerous patents were taken out covering these additions under various claims. This same condition is now being duplicated, there having been numerous patents granted recently covering the additions of various inert materials.

Improvement of flocculation by the addition of inert material is problematical and extremely controversial. Adding these to a sewage which can be efficiently flocculated by coagulating chemicals only tends to increase the amount of chemicals used by the added amount required to coagulate the clays, dusts, etc., with very dilute sewages it may be of some slight benefit due to the increased density obtained by this addition, possibly securing a more quickly settleable floc.

Benefit Is In Sludge Treatment Whatever benefit there is in these additions is not in improved flocculation, but rather in the improvement of the sludge cake. Paper pulp increases the fibre content of the dewatered sludge and makes it easier to handle. Clays, cement dust and other similar materials give a harder and more dense sludge cake. If the sludge is to be burned, paper pulp provides added heat for incineration, but clays, cement-dust, etc. increases the amount of fuel required. To improve the sludge cake, the inert materials should be added to the sludge and not to the sewage.

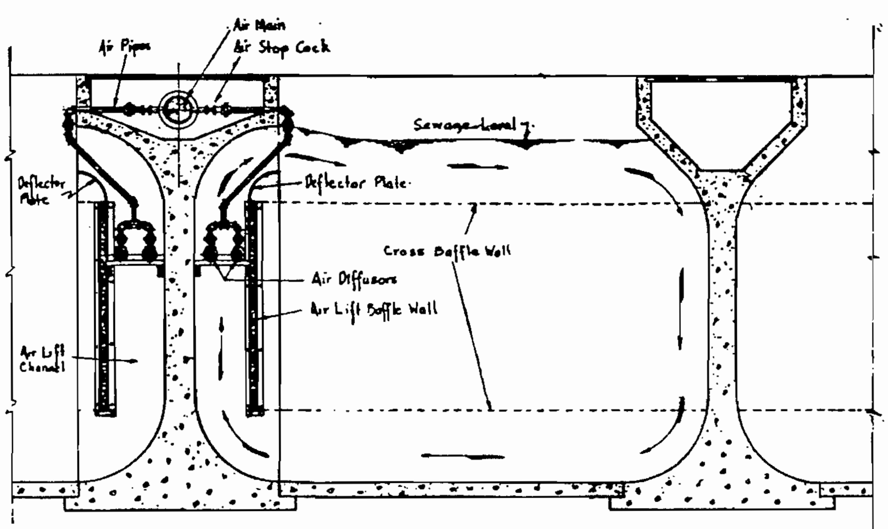

Fig. 5. Link-Belt flocculator.

Present Status The only large-scale operations adding inert material to the sewage are at Dearborn, where paper pulp is an integral part of the process, and at Atlanta on a 500,000 gpd experimental plant, where Cottrell dust was added. At Atlanta no definite conclusions were reached, and at the rebuilt Dearborn plant the use of paper pulp is being discontinued. Extensive experiments made by the authors indicated no improvement by the addition of either paper pulp or clays, the only effect noted being a tendency toward the more rapid clogging of the filter bed.

Flocculation and Mixing

General Principles Minute particles of insoluble substance are formed immediately following the introduction of the chemicals. These minute particles are not capable of crystallizing so that the growth of these, or agglutination, must be obtained by the aggregation of the minute particles. This aggregation is brought about by some external influence such as stirring or mixing, convection currents or sedimentation. Proper mechanical mixing or agitation causes a rapid aggregation of the particles, whereas with settling the particles are brought together at a very slow rate. Turbulent mixing causes the disintegration of the aggrandized floc and throws it back into the minute crystal or semi-solution form. Therefore the manner of mixing should be such as to effect a relatively slow, wide-sweeping motion in which the particles are brought gently into intimate contact with each other. The rate of floc formation is increased by an increase in the number of particles in a given volume of sewage (due to the increased probability that more floc particles will come together during mixing) as by the return of previously formed floc and the mixing of this with the chemically treated raw sewage; which also produces more efficient coagulation due to the characteristic of presenting a larger surface per unit of volume With an increase in the floc surface per unit of volume there is presented more area on which to build up the newly forming floc. Such a method requires a rapid primary mixing for dispersion, followed by a relatively slow secondary mixing for floc formation and the return of a portion of the secondary mix to the primary mix.

Types of Flocculators Various types of mixers, or so called flocculators, are available for use, and the designing engineer should carefully study all prevailing conditions to determine the type which seems best suited to the installation. It must be borne in mind, however, that the type of flocculating mechanism used, or its arrangement, is largely influenced by the kind of coagulating chemicals used. It would therefore be preferable to use a type which is adaptable to any combination of coagulating chemicals. Equipment for flocculation tanks is furnished by various manufacturers, some of which will be described.

The Dorr Company makes a combined flash-mixer and flocculator. The flash-mixer operates at a comparatively high speed and serves thoroughly to mix and diffuse the chemicals with the sewage. This is followed by a slow moving set of paddle wheels which give the sewage a slow rolling motion and causes an intermittent return of previously flocculated sewage to the lesser flocculated sewage.

The flocculator shown in Figure No. 4 (Filtration Equipment Corp.) consists of a mixing chamber in which the chemicals are mixed with the sewage, followed by a flocculating chamber having paddles parallel with the flow which are rotated about 90 degrees, imparting thereby an across the tank motion to the sewage. Both of these types cause a partial return of coagulated solids to, and mixing with, less coagulated matter and give the sewage progressively intermittent forward motion.

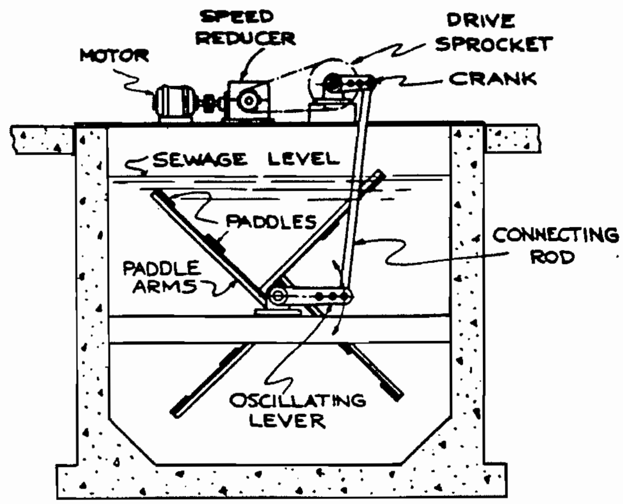

Fig. 4. Asch reciprocating floccer. Speed of paddles and length of stroke are adjustable.

Another type of flocculator, shown in Figure No. 5, (Link-Belt Co.), consists of elevated air diffuser tubes placed in an air lift channel constructed longitudinally with the tank. Air blown through the tubes imparts a rotary motion to the sewage in the tank and with sewage entering at one end causes it to flow forward in a spiral motion similar to the action obtaining in an aeration tank.

The flocculation tank shown in Figure No. 6 (Municipal Sanitary Service Corp.) consists of an influent pipe extended to the updraft tube where the chemically treated raw or pretreated sewage is mixed with previously flocculated sewage in any required proportion. The combined chemically treated raw and flocculated sewage is partially mixed in the draft tube, the mixing being completed in the air-lift head, which also produces circulation of the sewage in the tank. The air lift head is provided with curved diversion vanes which are entered across the splash plate and gives the sewage an outward spiralling or rolling motion, causing it to floc rapidly. A part of the flocculated sewage flows toward the center of the tank and is discharged from the tank through the effluent pipe. The balance of the flocculated sewage flows spirally downward and is mixed with the entering sewage. This type of tank is continuous in the mixing, flocculation, dispersion and diffusion, aeration, and in the reflocculation of the sewage solids.

Aeration of Sewage Aeration of the sewage immediately after the chemicals have been added is often advantageous and may, with certain sewage characteristics, result in more efficient coagulation. This aeration produces an effective mixing at a stage in the process when it is most needed. It also results in the liberation of carbon dioxide and other toxic gases present in the sewage. With a ferrous salt as the coagulant, aeration for oxygen absorption is an essential part in the formation of the insoluble ferric-hydroxide. Aeration is also a means of preventing any reversion of chemical reactions and causes them to go progressively forward to completion.

Precipitation or Settling

Tanks Mechanically Cleaned Tanks for precipitation and settling, or the separation of the coagulated solids from the sewage liquor, have a variety of forms and arrangements. Irrespective of the shape of the tank, mechanically operated scrapers should be provided for the continuous removal of the precipitated sludge. This is self-evident, as the deposited sludge contains the major portion of the organic matter of the sewage and unless this is continuously removed, decomposition will commence at a rate depending on the age of the solids, with the consequent return of putrefactive liquor to passed through a septic tank and stored in a second tank of sufficient size to allow for the storage of a one-week flow. When school is dismissed at the end of the week, the janitor treats the storage tank with a hypochloride solution in the amount of ten parts per million of available chlorine, and allows the tank to stand over night. The following morning the tank is flushed into the stream.

Septic Tanks That Have Failed to Function

In passing, it might be advantageous to point out some designs that have failed to operate. These tanks are producers of poor effluents, odors, and are generally a source of possible fly-borne infection. The different designs presented on the plate entitled "Diagrams of Septic Tanks That Have Failed to Function" are only three examples out of a large number of similar designs throughout the State.

Figure 1: This tank was installed for a school with one hundred and fifty resident pupils. The effluent was of poor quality causing fly and odor nuisance. The odor from the tank was most objectionable, particularly as the tank was located near the school.

The principles of design violated are:

(1) Short circuiting through the tank,
(2) In event the short circuiting did not exist, the tank has too small an area for an establishment of this size,
(3) No provision for sludge removal,
(4) No provision for gas disposal, and
(5) No provision for the proper treatment of the effluent.

Figure 2: This tank was designed for a city with a population of two thousand. At the time of first inspection, the sludge had reached a point indicated by the dotted line in the elevation section. Sewage was flowing up out of the manholes, "ponding" on the surface of the ground. The flow regulating valves had long ceased to function, through neglect and inaccessibility. The small amount of effluent escaping to the river was of poor quality, causing the worst possible conditions.

The principles of design violated are:

(1) Inefficient flow distribution,
(2) Insufficient sludge storage,
(3) Insufficient retention period,
(4) No provision for sludge removal,
(5) No provision for gas disposal, for the gas vents constructed were too small, were completely corroded, and did not diffuse the gas properly, and
(6) The effluent was improperly treated before discharging into the river.

Figure 3: There were unusual hydraulic conditions to be met in regard to this tank. The sewage reached the tank in large momentary flows from the pump. The short circuiting under these conditions would be certain with the facilities provided. The effluent was practically fresh sewage, and the odor and fly nuisance were terrible.

The principles of design violated are:

(1) Poor flow distribution,
(2) Insufficient sludge storage,
(3) Insufficient retention period,
(4) No provision for sludge removal,
(5) No provision for gas disposal, and
(6) No treatment of effluent before discharge into the river.

In conclusion, these suggestions and criticisms are presented with the hope of being of value to designers of this type of small system. At the present time, the designs of any disposal system are not required by legislation to pass before the Arizona State Board of Health for approval. The problem is, therefore, that of educating the public to the point that this approval will be demanded, and such conditions as heretofore, will not prevail.

Paper presented before Annual Convention of Arizona Public Health Association.

LIME TO BE RECLAIMED AT WINSTON-SALEM SEWAGE PLANT

Development of the Chemical and Mechanical Process of Sewage Treatment in Winston-Salem by the Excess Lime and Carbon Dioxide Method Involves Recalcining of Recovered Lime*

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A CHEMICAL and mechanical sewage disposal plant for the treatment of domestic sewage and industrial wastes was placed in operation in Winston-Salem, December, 1926. The process now in use consists of: mechanical bar screen, grit chamber, and fine screens; addition of lime to an excess caustic of 50 p.p.m.; electrolysis; clarification; thickening of slurry; and dewatering of sludge by vacuum filter.

Incineration of the dewatered sludge was part of the original plan, but the odorless sludge was so easily and cheaply disposed of, that this was never carried out. In fact, the sludge is removed at a profit to the City, and is used as a fertilizer.

The raw sewage entering the plant is quite strong, and carries large quantities of industrial wastes, mainly dyes. Although a satisfactory removal of organic matter is obtained, the effluent is often colored and sometimes turbid.

A large number of experiments have been made in the laboratory, during the past few years, to determine methods of improving the appearance, as well as the quality of the effluent. Some of the methods tried were: aeration; filtration through sand; magnetite, porous plates, and paper pulp; and precipitation with various coagulants, with and without lime.

While experimenting recently with iron and lime as coagulants, it was discovered that lime, added in large quantities, made an excellent coagulant. This gave a large, quick-settling floc, with unusually good clarification. The cost, however, was prohibitive. Reclaiming the lime seemed to be the solution. Apparently the previous plan of recalcining the lime sludge could be applied more advantageously to this method. It occurred to us that it would be possible to reclaim the excess lime in solution, by precipitating it with the carbon dioxide generated from the calcining sludge. This precipitated calcium carbonate would be recalcined also. Briefly, all lime added would be precipitated, dewatered, recalcined, and fed back into the inflowing raw sewage. This second precipitation leaves a supernatant that is clear and almost entirely free from color, regardless of the amount of dye in the raw sewage. This method was used successfully on strong dye wastes, which could not be clarified with 70 p.p.m. of ferric iron or phosphoric acid.

Lime Applied Ahead of Bar Screen

In plant operation, the plan is to add about 800 p.p.m. lime ahead of the bar screen, thus eliminating raw sewage odors, and use the detritor also as a classifier for the lime. The limed sewage will flow into one clarifier where the calcium carbonate and solids will settle out. The supernatant will then pass through the electrolyzers, where, laboratory results indicate, a higher degree of oxidation than is now obtained, will take place due to the high causticity; and from there to a carbonation tank where the carbon dioxide from the calcined sludge will be introduced. From this tank the sewage will flow into the second clarifier, where the calcium carbonate, formed from the carbon dioxide and lime in solution, will settle. The clear effluent will go into the creek, the settled calcium carbonate will be dewatered and calcined. By the use of this treatment, laboratory results show a 95% reduction of 5 days oxygen demand may be expected, as well as a very high percentage removal of solids and color.

Preliminary figures indicate the sludge can be recalcined for less than the cost of lime. About the only cost would be for the kiln, and an extra operator. On account of accumulation of impurities, it may be necessary to use a fresh batch of lime about every three months. This will require approximately 80 tons of lime a year, compared to 1,500 tons now used.

These laboratory experiments have been so gratifying that we are planning to build an experimental plant. If the results are confirmed under actual working conditions, this process will be incorporated in our regular plant.

*Paper presented before convention of North Carolina Section, American Water Works Association, Nov. 14, 1934.