CLEAN WATER

BIOLOGICAL TREATMENT OF WASTE WATER

1970 STATUS

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FORWARD

This report covers only projects funded under subprogram element 1705, "Dissolved Biodegradable Organic Removal", of the Planning-Programming-Budgeting-System (PPBS).

Information on sludge disposal and nutrient removal as related to biological treatment will be found in the yearly status reports of subprogram elements 1707 and 1701.

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PURE OXYGEN AERATION OF ACTIVATED SLUDGE

Linde Division of Union Carbide, under contract to FWQA, has completed a comparison of pure oxygen aeration and air aeration in the conventional activated sludge process. The study was carried out in identical parallel trains at the 2.5 mgd Batavia, New York Plant. Inefficient utilization of costly pure oxygen has discouraged similar full-scale operation in the past. The covered-staged oxygen injection and dissolution concepts developed by Linde overcome this obstacle and 90-95% utilization of the input oxygen was achieved.

The oxygenation system used employed sealed covers on the aeration tanks and intertank baffles to form a series of staged compartments. Each compartment or stage is equipped with a submerged turbine-rotating sparger unit and a recirculating gas compressor located on the top of the tank cover.

The three points demonstrated by this study with the greatest potential for reducing the cost of waste treatment are:

1. The substantial reduction in aeration volume possible with oxygen aeration while maintaining efficient carbon and solids removal. The oxygen train achieved better treatment in 1-1/2 hours aeration detention time than the air train at 3 hours.

2. The high solid content of the waste activated sludge achieved by the oxygen system; thereby, possibly eliminating the need for a separate thickener operation. Oxygenated sludge had a Sludge Volume Index of 40 and concentrated to about 3% in the final clarifier underflow.

3. The reduced quantity of waste sludge produced with oxygen. Significant reduction in the quantity of waste activated sludge produced by the oxygen system was noted. The best estimates at this time are that the reduction, by weight was 30-40%. Better data on the exact amount will be obtained this summer.

The economic substitution of pure oxygen for air may eventually prove to be one of the most significant breakthroughs in the history of the activated sludge process. The pure oxygen process, in addition to offering potential reduction in new plant construction, is also applicable to many existing high-rate or overloaded plants which are performing poorly.

A large scale R&D demonstration grant application is currently in Washington for funding consideration.

For more information, see report "Investigation of the Use of High Purity Oxygen Aeration in the Conventional Activated Sludge Process" by Linde Division of Union Carbide Corporation, Contract No. 14-12-465, or contact:

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TRICKLING FILTERS

There has been no major breakthrough in the past two years. This process is capable of producing a good quality effluent having a BOD_5 of less than 20 mg/l if lightly loaded. In the United States, the tendency is to load the filter at a much higher rate than is done in England. Thus, we find today many installations that will have difficulty in meeting the more stringent water quality standards.

It is not enough to just look for completely new processes, but attention and action must be given immediately to applying known technology to upgrading present treatment plants. All the needed new plants and plant expansion cannot be built in a short time. Substantial amounts of pollution can be prevented from reaching our surface waters by upgrading present plants. There are several ways of achieving higher removals. There is probably no one solution that will work at all installations, for each plant is different. If a plant is not getting good removal and the impairment is not due to toxic or grossly atypical waste, then it is usually due to either hydraulic overload, organic overload, or poor final liquid-solids separation. The following are suggested ways of alleviating these conditions.

Easing hydraulic overload

1. Find and reduce needless sources. Infiltration, downspouts, and cross connection can contribute greatly to the flow.

2. Use large interceptors as holding tanks. Many towns use their main interceptor to the plant to back-up the flow during the day and treat it at night when the flow is low.

3. Construct an equalizing or surge tank to smooth out the high peak flows. An equalization tank will mix and dilute toxic wastes, giving better downstream settling and lessen load fluctuations.

Aiding organic overloaded plants

Most organically overloaded plants can be aided by the same methods suggested for hydraulic overloads since they commonly occur concurrently. Additional methods are:

1. Have industry program the load for slow release. In smaller towns, most industries are willing to program extremely high organic waste flows.

2. Have industry treat at source using a roughing filter or other appropriate means to relieve part of the load.

3. Treat digester supernatant return by alternate methods or program return load to time of low load.

4. Remove more material in the primary tank by using iron or aluminum salts and polymers in the incoming waste. This will also remove phosphorus.

Lessen final solids discharge

One of the greatest improvements that can be made in secondary treatment is reliable solid removal from effluents. For efficient overall removal, the final settler must remove better than 98% of the solids. If overflow weirs are submerged several inches with the present flow, then there is no recourse except to increase settler capacity. For less hopeless cases, the following can be tried.

1. Chemical flocculation or precipitation in process or final effluent treatment.

2. Improve inlet and/or overflow design.

3. Install a microscreener.

4. Install mixed media filters.

5. Install tube settlers.

If a town has a trickling filter that is water tight or can be made so, the filter unit can be simply converted to an aeration tank. This can be done by removing the filter media and installing a surface aerator. The existing primary and final clarifiers can be utilized with minimal structural and piping changes. This type of conversion will usually increase the capacity of the plant twofold for a fraction of the cost of a completely new plant.

All the methods discussed are not new, but are well-proven processes. Thus, there are answers to the question on how a town can meet the new water quality standards. All that is needed is an awareness of the fundamentals involved and a willingness to pay for and use all the technology that is known.

ROTATING BIOLOGICAL DISCS

The rotating biological disc method of treating waste has been used in Europe for at least the last five years. The system basically consists of closely spaced rotating discs alternately submerged in wastewater and exposed to air. Wastewater continuously flows parallel to the discs. The waste level is slightly less than half the disc diameter. The units are usually arranged in series or stages.

The discs are molded of low-density expanded polystyrene. The entire downward load is offset by the buoyancy of the discs. Thus, the only power required to rotate the discs is that needed to overcome bearing friction. Microorganisms attach themselves to the discs and perform the same function as in a trickling filter. The biomass sloughed off the discs is removed in a final clarifier. In short, the rotating biological disc method is a modern version of the "Immersion Filter" developed by Buswell in the middle twenties.

FWQA has funded a grant (1701 EBM) with Rutgers University to assess the degree of treatment and to obtain operating data on this method of treatment. The pilot plant used in this study is a ten-staged unit with a design flow of 8 gpm. This gives a detention period of 5 minutes per stage or a 50-minute overall detention time for the disc unit. The plant has been in operation for about one year at the Jamaica Treatment Plant in New York City near the Kennedy International Airport. Data obtained thus far show that the unit is oxidizing about 93% of the biodegradable carbonaceous matter and 80% of the ammoniacal nitrogen in the primary effluent being treated. A report on the work is not available at this time.

A demonstration grant (11010 EBX) has been awarded to the Village of Pewaukee, Wisconsin to evaluate the effectiveness and efficiency of the rotating biological disc method for treating municipal wastes on a full-scale community level. The performance of the unit will be compared directly with an existing trickling filter under identical conditions. The design flow of the disc unit is 0.46 mgd. The unit is scheduled to be on-stream the latter part of this year.

The rotating disc system has an advantage over a trickling filter unit in that recycle is not necessary at night to keep the biological mass wet because the trough always contains liquid. It seems quite possible that the method can produce an effluent in quality some place between that of a trickling filter and an activated sludge unit. It is conceivable that the system would find application at some of our Federal installations, such as small parks or rest stations where there is a wide variation in the flows. There is a small two-stage unit available that handles population equivalents of 12 to 200 persons.

The main disadvantages of the method are that it must be housed to protect it from storms, hail, etc. and the large disc surface area required. For 90% removal, the unit load is 2.7 gal/day/ft^2 of disc surface area. Normally the discs are ten feet in diameter and the disc spacing is 0.846 inches.

INSTRUMENTATION OF WASTE TREATMENT PLANTS

Instrumentation and control have not yet caught up with the basic requirements of wastewater plants. There are several reasons for the limited use of continuous automatic analysis and control. Some of these are the absence of sensors to measure some of the most important factors directly, the fairly high cost of instruments available, and the willingness of those in the waste treatment field to decide that automatic operation is necessary and to take all the steps required to bring it to fruition. In the past, the cost of instrumentation has eliminated them from consideration by managers of small and medium-sized plants.

Recent emphasis on water quality standards is bringing about a natural increase in the extent of automatic control. This is especially evident in newer facilities where instrumentation is no longer an "afterthought", but an integrated part of plant design. Unfortunately, some engineers engaged in designing new plants have not kept up with the improved processing techniques. The design of a modern plant for treatment of wastewater requires a considerably broader knowledge of treatment and control techniques than in the past.

Many sensors cannot be used in treating wastewater because they become fouled by the gross solids, greases, oil, and aquatic growths. Despite the encumbrances inherent in the physical makeup of raw wastewater and sludge drawoff, measuring devices and instrumentation are now available that can monitor and control most of the secondary plant flow systems. The real problem in automating the various flow regimes is not a lack of flow controlling equipment, but the inability to rapidly measure biological activity or "state-of-health" of the system. For instance, wasting of activated sludge could logically be based on the active mass of microorganisms in the system. However, the closest we can come now to determining active mass is mixed liquor volatile suspended solids and this has been estimated to represent 50 to 100 percent more active solids than are actually present. Thus, the difficulty in controlling the treatment plant is directly attributable to the inability to model constantly changing life processes.

It would appear that the best index for understanding and controlling the activated sludge process would be the amount of living cells in the aeration tank. No method now exists which permits determination of the microbial activity in a manner useful to process control. Adenosinetriphosphate (ATP) is present in and essential to all living cells. Measurement of ATP would be a rapid and unequivocal method for active microbial mass. Biospherics Incorporated is under contract (14-12-149) to design and fabricate an instrument for use in the ATP assay. In addition, they will adapt the firefly bioluminescent method to determine the ATP of activated sludge which is directly proportional to the biomass. E.I. DuPont is now producing commercially the reagents needed for the test; therefore, there will not be any difficulty in obtaining the reagents if the method becomes a reality. This method probably can be automated. The time to perform the tests should be about 15 minutes if done manually.

Biological process efficiency is now measured by various laboratory analytical techniques. The time required to collect, transfer samples, and perform the analyses may take anywhere from three hours to five days. The time involved in obtaining data seriously hinders rapid and effective process control. On-line instrumentation designed to yield reliable, useful information in terms of minutes instead of hours would contribute significantly to improving plant operation. Contracts are now being let to develop an on-line instrument to measure the organic strength of influent and effluent streams at a waste treatment plant. The instrument will be capable of analyzing both filtered and unfiltered samples. This will entail developing an on-line macerating device as well as an on-line filter. Within the next year, it is hopeful that a full automatic on-line COD and TOC analyzer will be available to treatment plants.

A wastewater treatment plant can have too much instrumentation and automation or it cannot have enough. Most wastewater treatment plants now have too little instrumentation to give adequate control. The new pilot plant at AWTRL in Cincinnati will test new process control equipment and instruments in the coming year. The aim here is to operate them under controlled conditions to determine durability, performance, and limitation. This information will then be made available to construction grants people and consultants so that new plants can be operated more efficiently.