Proceedings of the

29th Industrial Waste Conference

1974

Part 2

Engineering Extension series No. 145

Proceedings of the 29th Industrial Waste Conference

May 7, 8, and 9, 1974

Part Two

The Purdue Industrial Waste Conference is under the direction of:

The School of Civil Engineering
The Division of Conferences and Continuation Services

in cooperation with the

Indiana State Board of Health
Indiana Stream Pollution Control Board
Indiana Department of Natural Resources
Indiana Section of the American Water Works Association
Indiana Water Pollution Control Association
Indiana Section American Society of Civil Engineers

Purdue University . Lafayette, Indiana

The Awakened Interest in the Sewer Ordinance

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WHY ARE SEWER ORDINANCES NEEDED?

Sewer ordinances form the legal basis for the protection of the public Health as affected by the sanitary collection and disposal of a community's wastewaters. Ordinances are needed to protect the community's natural resources, to regulate the use of the sewerage works and to prevent improper use of the sewerage works. Good ordinances set forth in an available written form the rules and regulations needed to control the use of the sewerage works. Such rules are needed in order to maximize the use of the sewerage works within the limits of its capacity and to ensure that all users, both present and potential, are treated equitably.

It is not often that it becomes necessary to resort to legal means to control the use of the sewerage system, however, it is necessary to have clearly defined authority to do so when such occasions arise.

Ordinances are also a means for educating the users of the sewerage system in regard to the proper uses for the system. Adequate rules and regulations will tend to discourage the development of improper uses of the sewerage system or uses which are beyond its capabilities.

WHY ARE NEW ORDINANCES NEEDED?

Many cities and towns throughout the country are in the need of rewriting and modernizing their existing ordinances or even of adopting ordinances. It may be asked "Why are new ordinances needed at this time?" Modernized ordinances are needed because many of the old ordinances were written primarily with the operation of the sewerage collection system as the principle objective. At the time many of the older ordinances were adopted, there was no wastewater treatment provided or the wastewater treatment was limited to primary treatment. Many of the industries within a community discharged their industrial wastewaters directly to the environment, generally without treatment. With the universal requirement that all systems provide at least the equivalent of secondary biological treatment and that no untreated wastes be discharged to the environment it has now become necessary to regulate the discharges to the sewerage system to such materials as can be adequately treated by the municipal treatment system.

New chemicals are being manufactured and used at an ever increasing rate. The effect of many of these new materials on the sewage treatment processes and the environment are not clearly understood. Stream standards and effluent standards have been upgraded such that a municipality may become responsible for materials which pass through its wastewater treatment system in excessive amounts. However, there are new treatment methods available such as: physical chemical systems which permit a municipal treatment works to adequately remove many pollutants which formerly would not have been acceptable in the system.

Materials such as radioactive isotopes are now in wide use in many hospitals, so there is the ever present possibility of an accidental spillage into the sewer system. The ordinance would provide for the posting of instructions for emergency procedures at locations where accidents may occur. For example, the instructions on what to do in case an accidental spillage of radioactive isotopes or other hazardous materials occurs, would include: 1) telephone the wastewater treatment plant superintendent to inform him of the situation; 2) contact authorities to institute a program of monitoring, search and recovery to try and locate the isotopes in the sewer system; and 3) establish whether isotopes can be recovered and plan to recover them or, whether they have passed through the entire system into the receiving water, calculating its active half-life and its dispersion and dilution factor from the point of protecting the likelihood of human contact.

Chlorinated organic compounds such as chlorophenols and PCB's etc. which are used in the production of new insecticides are toxic to bacterial life forms contained in activated sludge.

The ordinance would either exclude their discharge into the system entirely or specify allowable concentrations and rates of discharge at which these compounds could be treated. Slug or shock loadings of these compounds would completely render inactive biological activated sludge treatment plants; and would therefore be specifically prohibited by the ordinance.

Furthermore, Public Law 92-500, the Federal Water Pollution Control Act Amendments of 1972, Section 204(b) (1) (A, B & C) requires that all applicants for federal assistance in the construction of sewerage works adopt a system of charges to assure that each recipient of wastewater treatment services, within the applicant's jurisdiction, will pay its proportionate share of the costs of operation, maintenance (including replacement) and expansion of any waste treatment services provided by the applicant; has made provision for the payment to such applicant by the industrial users of the waste treatment works, of that portion of the construction of such treatment works which is allocatable to the treatment of such industrial wastes to the extent attributable to the federal share of the cost of construction; and has legal, institutional, management, and financial capability. The basis for the proposed charges should be clearly set forth in the ordinance in order that all users will be aware of the magnitude of the charges and the municipality will have the legal ability to collect the charges. Examples of typical user charges are given later in the *Design of the Ordinance* section.

PLANNING FOR THE NEW ORDINANCE

Planning for the new ordinance should start during the preliminary planning processes, during the conception of a new sewerage system or the upgrading of an existing system.

Before a new ordinance is written, the governing and administrative body must reach certain policy decisions to ensure that the general public and industrial users get the most cost effective and best practical treatment processes to treat their totally combined or partially combined wastewaters. EPA has published Guidelines for Facilities Planning (1) which set out detailed requirements which they insist upon before a federal grant can be made on any project.

Decisions which need to be made are: 1) For what capacity should the system be designed? (This decision is essentially concerned with the industrial wastewaters. Will industries which have large volumes of waste be accepted and provided for?); 2) Which wastes will be treated and which will be excluded (2)?; 3) Who is going to administer and operate the sewerage works?; and 4) How are the works and the operation to be paid for?

The necessary decisions cannot be made without an intimate knowledge of the system. This means that it will be necessary to make an industrial wastes survey during which the volume, strength and characteristics of all of the major industrial wastes will be determined.

It is essential during this survey that industry be as cooperative and honest as possible, so that the planners obtain accurate data on wastes presently being discharged, plus future projected waste discharges and whether their character will change due to changes in production items. This will enable realistic treatment process selection and evaluation.

We realize that this is a difficult question to pose to industries whose whole future depends on its competitive position. The planners can assist industry at this time by providing them with the following information: 1) Range of industrial user charges based on existing projects which could be levied at an industry; 2) Advantages of participating in the system; i.e. relieved of any staff operation and maintenance responsibilities; eliminate need to use their own industrial zone land for wastewater facilities, etc.; 3) During industrial waste survey, planners can indicate to the industry ways it can cut down on its waste discharges (for example: Water use evaluation; Possible changes in manufacturing ingredients which do not exhibit a BOD or COD load, i.e. paper making retention aids; and Recycling of minutely contaminated wastewaters); and 4) An industry may consider availability of sewerage discharge and treatment facilities as an intangible asset to the overall wealth of the company. In the event of the resale of the business the availability of such facilities will certainly be of considerable importance to potential purchasers. This asset should be made available to industry by making the ordinance as broad as possible within the capabilities of the sewerage system.

A survey will be needed of the sewerage system to determine the nature of the flows, that is, the variations throughout the day and the strength of the wastewater. The strength of the wastewater will depend to a large extent on the amount of infiltration into the system. The degree to which roof leaders, foundations drains and areaway drains are connected to the system should also be estimated.

The amount of inflow-infiltration must be ascertained to determine whether it is excessive or not before a grant may be given by EPA. (Refer to Public Law 92-500, Section 201 (g) (3).)

Once facts concerning the existing system are known, the various alternates for collection and treatment should be developed and evaluated. Included in the evaluation of the alternates, should be the estimated costs, the requirements of the receiving waters, the requirements of the Environmental Protection Agency, the public policy of the community and the technical capabilities of the community. For example, it would appear to be unrealistic for a community of a few thousand people to attempt to design, construct, finance and operate a municipal treatment plant which included the industrial wastewaters from a large, complex refinery. On the other hand, many communities are able to render valuable services to their industries by providing sewerage treatment services.

If the public policy is to encourage industry, then the ordinance will allow certain industrial wastes and will treat them to tolerable levels suitable for discharge into the receiving waters. The community may then conceivably attract additional similar industries in these areas which in turn would help the local economy and provide jobs.

On the other hand it may be the public policy of the community to discourage industry in which event the sewer ordinance may be very restrictive.

Once the various alternatives have been evaluated and costs assigned to them, the general public including industries should be involved in the formulation of the public policy of the community. The projected costs and benefits of the various alternatives should be explained to the public and the industries. For those industries for which it would appear advantageous to join the system, a firm commitment for inclusion or exclusion should be obtained. Consideration should be given to the possible movement of other industries to the area in the future.

With this information in hand, the design of the sewerage works can be decided upon. An ordinance may then be drawn up which will permit the maximum utilization of the capacity and ca[illegible]es of the proposed sewerage works.

It is necessary to make a policy decision concerning who will administer and operate the sewerage works. This may be a city council, a Department of Public Works, a sewerage board, or an independent authority. It would appear to us that only in the smallest communities would the governing body such as the city council retain the day-to-day administration and operation of the sewerage works.

Finally, in determing the policy on who pays for the cost of the sewerage service, a number of alternative methods have been used. Sanitary sewage service may be paid for from the municipal tax system. This method has the advantage of elimination of billing for the individual householder and the cost of the service to the individual householder can be offset to some extent against state and federal taxes. However, under this system people owning large properties will pay a larger proportion of the cost than those people living in more modest homes. Another system of charges is to base the charge upon a percentage of the water bill. Under this system each user pays in accordance with the volume of water contributed to the sewerage system. However, under this system the payments cannot be offset on the state and federal taxes by an individual. Finally, if the federal government has contributed to the cost of construction of the works, it is necessary to establish individual charges for industry, for that portion of the costs paid for with federal funds. The Environmental Protection Agency has established guidelines for this cost recovery procedure. Refer to Title 40 — Protection of Environment, Chapter I — Environment Protection Agency; Sub-Chapter D — Grants; Part 35 — State and Local Assistance; Sub-Part E — Grants for construction of Treatment Works, Federal Water Pollution Control Act Amendments of 1972; which were published in the Federal Register, Volume 38, No. 161 on Tuesday, August 21, 1973.

THE NEW ORDINANCE

It is not the intention of this paper to discuss in detail all of the items which should be included in a sewer ordinance. Most of these are well documented in the Manual of Practice No. 3 "Regulation of Sewer Use" published by the Water Pollution Control Federation. We have also found it useful to review the ordinances of a number of other communities to assist us in preparing a new ordinance for a community. Probably, no existing ordinance will be entirely satisfactory. Each ordinance was designed with specific local conditions in mind and, therefore, cannot be transferred or applied to an entirely different community. The following are certain comments we have concerning the construction of an ordinance:

BASIC PHILOSOPHY OF AN ORDINANCE

The ordinance should permit maximum utilization of the sewerage works consistent with the protection of public health, protection of the works, the safety of the operating personnel and the efficiency of the treatment processes. This means the industry should be given every encouragement possible to enter the system, even if pretreatment of some of the wastes by industry is necessary. The ordinance should be written in such a way as to be equitable to all potential users of the system. This is sometimes difficult when making decisions as to which industries are to be included and which should be excluded. Furthermore, it means that costs should be allocated on the basis of use by each contributor in proportion to the costs to treat its wastes. One successful type of financing takes the form of financing the basic operation from property taxes, plus a surcharge for excessive use.

The author of rules to regulate or control the discharge of industrial wastewaters into a municipal sewerage system is faced with a number of problems, the solutions of which are incompatible. The primary problem is to protect the public health. The easy answer to this problem is to prohibit the discharge of any industrial wastes to the municipal sewerage system. There are, however, many if not most, industrial wastewaters which are innocuous to the public health which would however create excessive hardship to the industries if disposal on an individual basis were required. Hence, exclusion of such waste-waters from the public sewerage system cannot be justified.

The question of toxic wastes from industry also arises. Which wastes are innocuous and which are toxic? It should be noted at this point that toxicity referred to hereinafter in this discussion is not limited to human toxicity but includes all aspects of the environment, including plants, animals, fishes, and microscopic life. The question of toxicity is often a question of concentration.

Toxicity is not the only reason for limiting the amounts of certain materials which may be safely discharged to the sewerage system. Some normally innocuous materials such as salt, calcium carbonate, sand, clay, oil, fibers, plastics and similar materials may interfere with the operation of the collection system or the sewerage treatment processes. If they are present in excessive amounts, they can cause stoppages in the collection system. They can overload some treatment units and they can cause the failure of biological systems by occupying too much of the available space. Other materials in excessive quantities are considered pollutants in that they interfere with the desirable uses of the receiving waters.

The next question which arises is at what point in the system should the concentrations of toxic materials be required to be harmless? Should it be at the point at which it leaves the industry and enters the public system? To impose this requirement would deny the value provided by the dilution available from the large volumes of sewage in the system. In the interest of minimizing the overall costs of wastewater disposal, it is essential to utilize all available resources. Dilution by wastewaters from other sources is a resource available without cost. Hence, we recommend that the criteria for the discharge of toxic materials to the sewerage system be such that no toxic concentrations will occur at the end of the collection system, at which point the material will enter the environment.

DESIGN OF THE ORDINANCE

An ordinance generally has about 5 parts 1) Definitions — This section defines all of the special terms used in the ordinance and helps to eliminate differences of interpretation that may result in unnecessary dispute and litigation; 2) The conditions for discharge to the system (This section generally describes who must discharge to the system, the manner in which the connections shall be made and includes a requirement, or should include a requirement, that a permit be obtained from the designated authority to connect to, and discharge to the system); 3) The limitations on what may be discharged to the sewerage system; 4) The powers of the authority to inspect, to level penalties and to prohibit discharges (This section usually describes appeal procedures for those who feel agrieved by a decision of the administering authority); and 5) a description of the cost assessments.

There are certain principles which we have developed for designing a rate system for wastewater treatment charges. In developing the rate system two basic components are used. These are: the capital cost of the system and the operating costs. Both capital and operating costs are broken down into three basic components with the possible addition of a fourth in special cases. The components used in subdividing the capital and operating costs are: flow, BOD and suspended solids and a fourth cost which is related to any special or unusual situation or material. The cost of construction, operation and maintenance of the sewerage collection system is considered to be entirely related to flow and these costs are assignable to the individual user completely on the basis of the flow contributed to the system. It may be argued that the proper flow to use should be the peak flow since the sewerage system is designed to handle these flows. However, up until the present time we have utilized average daily flow.

In determining the portion of the rate due to the construction, operation and maintenance of the treatment works we examine each unit operation and divide the costs of construction between the elements of flow, BOD and suspended solids in proportion to the influence these elements have in the design of the particular unit operation. For example, the volume of a sedimentation basin is primarily a function of the volume and rate of flow, whereas, the sludge removal facilities are related to the suspended solids. BOD had little, if any, influence upon the design of a sedimentation basin. Most of the cost of sedimentation is, therefore, attributable to flow.

On the other hand, the design of an activated sludge aeration basin is dependent upon the BOD and to some extent upon the required detention time. Hence, the aeration basin costs are allocated between flow and BOD with none of the costs assignable to suspended solids. The costs of aeration equipment are completely assignable to the BOD. In a similar manner, the cost of each treatment unit may be divided among the three components described. When all costs have been determined and summarized the capital costs attributable to flow, to BOD, and to suspended solids will have been determined. They may then be reduced to dollars per million gallons per day of flow, dollars per thousand pounds of BOD and dollars per thousand pounds of suspended solids.

Likewise, the operating costs of each unit process may be divided among the three components. In certain instances a fourth component covering special requirements may be added. An example of a special component would be an unusual chlorine demand requiring the use of excessive chlorine. Another example might be the necessity for adding lime or alum to remove an excessive concentration of phosphate. The costs, both capital and operating, for such special items should be charged directly to the contributor of the wastes necessitating these special requirements.

A more detailed breakdown of two examples of the methods used may be found in the Appendix to this paper. The first is for the Greater Lawrence Sanitary District in Massachusetts which is a more or less standard activated sludge plant and the second is the wastewater treatment plant at Niagara Falls, New York which is a physical chemical plant consisting of chemical precipitation followed by activated carbon adsorption. As an example of the magnitude of these charges in Lawrence the capital costs will be about $50 for each million gallons of flow, $5.50 for each 1,000 pounds of BOD and $4.50 for each 1,000 pounds of suspended solids. In addition to the construction costs the annual costs due to operation and maintenance will be $80 per mgd, $15.00 per 1,000 pounds of BOD and $6.50 per 1,000 pounds of suspended solids.

The capital costs are based on 30 year bonds at 5% interest with the principal being retired in equal installments and the interest being paid on the outstanding balance.

After the ordinance has been drafted, copies should be made available to industry and to the general public and after appropriate notice, public hearings should be held at which time comments should be received from the general public and from industry. It is sometimes helpful to have private working sessions with some of the larger industries which may have a greater impact on the sewerage works.

Finally, the ordinance should be formally adopted by the governing body having the jurisdiction and authority to adopt the rules.

After adoption, it is necessary to develop an enforcement procedure. The best ordinance is of little effect if it is not enforced. The method of enforcement will depend a great deal on the size of the community being served. In a small community the sewer superintendent may make periodic inspections of the system. On the other hand, a large system may employ one of more inspectors whose only duties would be the inspection of new installations and the checking of existing installation. The inspections would be assisted by appropriate laboratory analysis, by monitoring and reporting by the industries of their own waste discharges.

FUTURE CHANGES

An ordinance once adopted cannot be considered as an unchangeable law which fixes everything at the status quo. As mentioned at the beginning of this paper, changing conditions require changing and upgrading of any ordinance. An example of the necessity for changing an ordinance might be the desire of a large new important industry wishing to establish itself in the community. The designers of any ordinances cannot foresee all possible future applications of this nature. At such time as such an event takes place, the officials having responsibility and authority for adopting ordinances must consider the implications of altering the existing ordinance to accomodate the changed condition.

In addition to these, another major result will enable the inevitable use of more of the nation's streams and rivers for supplies of raw water for treatment into drinking water. It is conceivable that future generations will recycle wastewater effluents directly into water treatment plants to produce drinking and industrial waters. In fact, today there are several wastewater reclamation plants in service and under construction in the U.S. and throughout the world.

APPENDIX

1. *Greater Lawrence Sanitary District, Massachusetts*

INDUSTRIAL USER CHARGE FORMULAS

Capital Costs

$$\text{Each Industry's annual share} = \left[\frac{Fi}{52} \times 60\% \times CC\right] + \left[\frac{BODi}{47{,}000} \times 20\% \times CC\right] + \left[\frac{SS_i}{61{,}000} \times 20\% \times CC\right]$$

Legend No. 1

F_i —Average daily flow of wastewater discharged by an industry (expressed as mgd) over the time period of the cost allocation. (Volume ÷ calendar days in time period.)

BOD_i—Average daily amount of BOD discharged by an industry (expressed as pounds/day) over the time period of the cost allocation (Total pounds BOD ÷ calendar days in time period.)

SS_i —Average daily amount of SS discharged by an industry (expressed in pounds/day) over the time period of the cost allocation. (total pounds SS ÷ calendar days in time period.)

CC —Amount of annual capital cost (principal and interest payments on bonds plus other costs as indicated in Chapter 750 of the Acts of 1968 as amended by Chapter 320 of the Acts of 1970) to be shared in by industry (District's share for Contracts 1, 2, and 3 and the Federal grant amount for Contracts 4 and 5 divided by the service life of the facility or the time of bond repayments, whichever is less.)

mgd —Million gallons per day wastewater flow.

BOD —Biochemical Oxygen Demand (5-day, 20 C)

SS —Suspended Solids.

Operation & Maintenance Costs

Each industry's estimated annual share $= [\frac{F_i}{F_T} \times 80\% \times OM]$

$$+ [\frac{BOD_i}{BOD_T} \times 12\% \times OM]$$

$$+ [\frac{SS_i}{SS_T} \times 8\% \times OM]$$

Legend No. 2

F_i, BOD_i and SS_i as above in Legend No. 1.

OM —Annual Operation and Maintenance costs (as indicated in Chapter 750 of the Acts of 1968 as amended by Chapter 320 of the Acts of 1970) for all Contracts.

F_T, BOD_T and SS_T — Average first year total daily flow, BOD and SS respectively to the treatment facilities.

It is of interest to note that on this particular project the parameter resulting in greatest capital and O & M cost is FLOW. It is reasonable to assume that this parameter of FLOW will be always the major contributing factor to costs levied against industry so it is obvious to conclude that industry should concentrate on reducing its wastes flows at every opportunity.

The District will require from each industry as part of its permit application an agreement on the amount of Flow, BOD and SS expected from the industry and that the District reserves the right to assess a surcharge on the industry should its discharge exceed that stated.

If, in the future, treatment requirements change such that other factors in addition to Flow, BOD and SS must be considered, the above formulas and percentages will be modified accordingly.

NOTE: The Figures 52; 47,000 and 61,000 represent the following: 1995 year design average figures for average flow; lbs of BOD per day and lbs of suspended solids per day.

2. *Niagara Falls, New York*

DEFINITIONS OF TERMS & VARIABLES USED IN COMPUTING THE RATE SCHEDULE FOR COLLECTION & TREATMENT OF WASTEWATER AT NIAGARA FALLS, N.Y.

Participant = Any contributor to the sewerage system who has an average daily wastewater flow equal to or greater than 100,000 gallons, or who has either an average daily suspended solids loading, or an average daily total COD loading of 250 pounds or more.

Participants will pay the following rates:

A. Flow charge = A1 + A2 + A5 + A7
B. Suspended Solids Surcharge = S5 + S6
C. Soluble COD Surcharge = O5 + O6

BASIC DEFINITIONS

A1 = Flow charge, in dollars per million gallons. It is based on the annual operation and maintenance costs for the collection system.

A2 = Flow charge, in dollars per million gallons. It is based on the annual capital costs for the collection system.

A4 = Total annual operation and maintenance costs for the Wastewater Treatment Plant (WWTP) which are assignable to flow.

A5 = Flow charge, in dollars per million gallons. It is based on "A4" described above.

A6 = Total annual capital costs for WWTP, including land, which are assignable to flow.

A7 = Flow charge, in dollars per million gallons, based on "A6" described above.

S4 = Total Annual operation and Maintenance costs for the WWTP which are assignable to suspended solids.

S5 = Surcharge for suspended solids in excess of an average of 250 lbs per day, in dollars per pound. It is based on "S4" described in the previous page.

S6 = Surcharge for suspended solids in excess of an average of 250 lbs per day, in dollars per pound. It is based on the total annual capital costs for the WWTP which are assignable to suspended solids.

O4 = Total annual operation and maintenance costs for the WWTP which are assignable to soluble chemical oxygen demand (COD).

O5 = Surcharge for soluble COD portion of the total COD in excess of an average of 250 lbs per day, in dollars per pound. It is based on "O4" described above.

O6 = Surcharge for soluble COD portion of the total COD in excess of an average of 250 lbs per day, in dollars per pound. It is based on the total annual capital costs for the WWTP which are assignable to soluble COD.

REFERENCES

1. "Preliminary Guidelines for Facilities Planning" — Section 201, Public Law 92-500, Published — January, 1974.

2. Possible pretreatment requirements for known incompatible pollutants. EPA official definition of compatible and incompatible pollution plus pretreatment standards can be referred to in Title 40 — Protection of the Environment, Chapter I, — Environment Protection Agency; Sub-Chapter D — Water Programs, Part 128 — Pretreatment Standards, which were published in the Federal Register, Volume 38, No. 215 on Thursday, November 8, 1973.

Laboratory Studies into the Reduction of Pollution From Poultry Processing by In-Plant Recycle

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INTRODUCTION

As the wastewater discharge limits imposed on polluting industries become more stringent, manufacturers must find new technology and process modifications to allow them to continue operation. The poultry processing industry is an example. Faced with the problem of continually upgrading the quality of its discharged wastewater, it must develop new concepts for wastewater treatment or in-plant water use.

The proposed discharge limitations under the NPDES permit system for poultry processing plants are 0.40 pounds of BOD_5 per 1,000 pounds of broilers processed and 0.62 pounds of suspended solids per 1,000 pounds of broilers processed. Slightly higher allowances are made for the processing of heavier birds, referred to as foul, amounting to 0.46 pounds of BOD_5 and 0.62 pounds of suspended solids per 1,000 pounds of birds processed.

These limitations amount to more than 98 percent removal of BOD, suspended solids and oil and grease for most poultry processing plants (1, 2, 3, 4). They were based on the performance of a wastewater treatment system in Florida which incorporated high detention time aerated lagoons and a polishing pond (4). This type of system is not a viable alternative for plants which have limited land area available to them or are located in a colder climate. The only means by which these plants can meet the proposed limitations are by the use of tertiary treatment, by conversion to "dry" processing methods, or by the in-plant recycle of water.

The work reported on in this paper is the first phase of an on-going project directed toward determining the feasibility of in-plant wastewater treatment and recycle. The basic questions addressed are: Can poultry processing wastewater be treated sufficiently to allow its safe reuse? Is the treatment and reuse concept economically feasible? How does the cost of treatment and reuse of individual unit processing wastewaters compare to the cost of tertiary treatment of the combined plant wastewater flow?

The approach taken to develop answers to these questions was to study the treatability of both the total combined wastewater flow from a poultry processing operation as well as waste flows from certain individual unit processes within the plant. The treatment methods studied were of the physico-chemical type.

Figure 1 presents a schematic of a typical poultry processing plant. Live birds are received, killed, bled, then immersed in a hot water bath called a scalder. They are then defeathered and washed, then eviscerated. Next, they are cooled in an icewater bath called a chiller, then packed for shipping or sent to "further processing." There are three major sources of wastewater; the scalder, the eviscera carriage flume and the chiller. Other wastewater sources result from feather carriage, bird washing, hand washing and plant washdown.

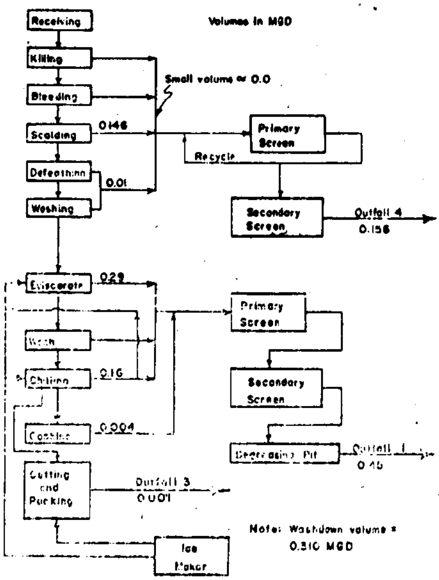

Figure 1 — Schematic of poultry processing plant.

At the present time, many poultry processing plants which have treatment combine all wastewater flows and treat by dissolved air flotation or air dispersion. The degree of treatment thus accomplished is not sufficient to meet the proposed NPDES requirements; therefore, if a municipal system is not available to further treat the wastewaters, a choice of two alternatives must be made. Additional treatment equivalent to tertiary treatment or reduction of pollutants by process change or wastewater treatment recycle within the plant.

It might seem obvious that the most sensible method for reducing pollutants from the viscera carriage flume would be to replace the system with a "dry carriage" device. However, this sort of solution is not as apparent for two other major pollutant sources, the scalder and the chiller. "Dry" scalding, i.e., using steam rather than a hotwater bath, might result in deterioration of the quality of the finished product. "Dry" chilling, using a cold air blast rather than an ice water bath, would result in a different moisture content of the finished product.

A possible solution, then to the problem of reduction of pollutants from the chiller and/or the scalder would be to treat and recycle water from each individual process using a physico-chemical system consisting of screening, chemical coagulation, dissolved air flotation, sand filtration, activated carbon adsorption and disinfection. Heat conservation should also be employed for economic as well as bacterial control reasons. Figure 2 presents a schematic of such a treatment system.

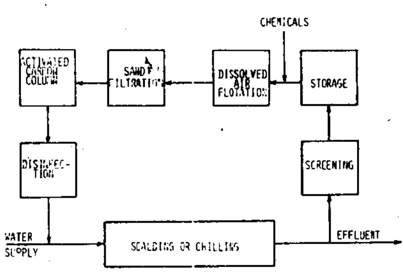

Figure 2 — Possible wastewater recycle method.

This paper presents the results of an investigation into the treatment concepts and design criteria for a discharge elimination — process water conservation system for poultry processing operations. Laboratory scale batch and continuous flow pilot plant data are presented.

EXPERIMENTAL WASTEWATERS

The wastewaters used for this experimentation were obtained from two poultry processing plants, both located in Belfast, Maine. Each of these plants has a dissolved air flotation treatment system employing chemical coagulation using alum and a polymer. The degree of treatment accomplished by each of these plants ranges between 85 and 95 percent removal of BOD_5, suspended solids and grease. Figure 3 shows a schematic diagram of the type of system used by each of these plants.

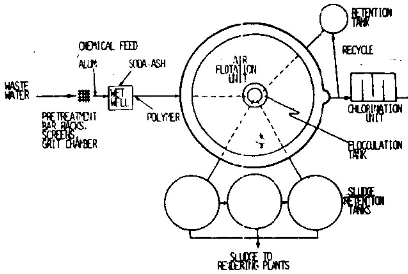

Figure 3 — Schematic of existing treatment plant.

The samples of waste scalder water were obtained from the scalder overflow during the afternoon hours. The samples of waste chiller water were obtained from the chiller overflow during either mid-morning or afternoon.

EXPERIMENTAL PROCEDURES

Studies of treatment characteristics were conducted on four of the physico-chemical treatment processes diagramed in Figure 2. The experimental procedure consisted of coagulation and flocculation of the wastes followed by dissolved air flotation, sand filtration and activated carbon adsorption, in that order. Apparatus included a laboratory stirring device, a pressure cell for dissolving air in tap water, a nephelometer to measure percent transmittance, a total organic carbon analyzer, plus pilot scale sand filter and activated carbon beds. Wastewater was placed in each of six beakers located under a six-place laboratory stirring apparatus. During rapid mixing, alum was added followed by a polymer. After slow mixing for a prescribed time period water supersaturated with air was introduced to the bottom of the contents of each beaker. The resulting minute air bubbles carried the flocculated material to the surface.

Chemical coagulation studies were conducted on waste overflows from both the scalder and the chiller. The aluminum sulfate solution used was prepared from dry analytical grade aluminum sulfate ($Al_2(SO_4)_3 \cdot 18\ H_2O$). No attempt was made to artificially age the solutions, although new solutions were allowed to stand 24 hours at 23 C before use.

A total of fourteen commercial polymers were evaluated as to treatment performance. The polymers were supplied by the Dow Chemical Company, Midland, Michigan; Calgon Corporation, Pittsburg, Pa.; and American Cyanamid, Stamford, Connecticut. Solutions of the polymers were prepared according to manufacturer's instructions using distilled, deionized water.

Adjustments of pH and alkalinity were made with NaOH, H_2SO_4, and Na_2CO_3.

Dissolved air for the flotation studies was produced using the apparatus shown in

Figure 4. This apparatus was constructed of a plexiglas tube with a 5.5 in. (14 cm) inside diameter and 11.5 in (29 cm) in length. Wall thickness was 0.25 in (0.64 cm). With proper adjustment of the valves and air pressure it was possible to operate the system in a continuous mode. The retention time of the liquid in the tank when operated in the continuous mode was about five minutes at a liquid flow of about 750 ml per minute. Materials which came in contact with the wastewater-polymer systems were coated with Siliclad, a commercial silicone coating, to eliminate adsorption of the polymer on the glassware and paddles.

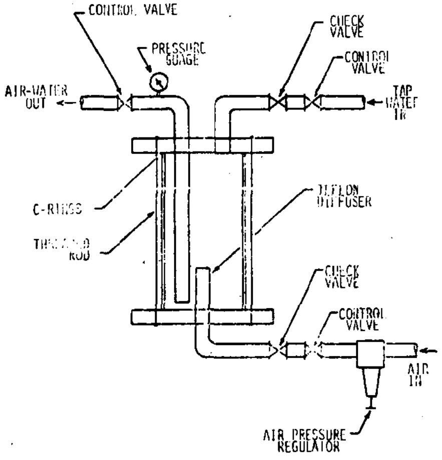

Figure 4 — Apparatus used to dissolve air in tap water.

A Beckman Model 915 Total Organic Carbon Analyzer was used to measure dissolved organic material in the raw and treated waste. Before analysis each sample was filtered through glass fiber filter discs to remove suspended solids which, because of nonuniform distribution, could have introduced errors in the analysis of small sample volumes. Since the total organic carbon (TOC) analysis was performed on the filtrate, it provided a measure of the dissolved organic carbon in the original unfiltered sample.

Sand filtration studies and activated carbon adsorption studies were carried out using the apparatus diagramed in Figure 5. Initially, isotherm studies were conducted to evaluate the probable effectiveness of a number of different activated carbon samples, obtained from several different manufacturers. It has been recommended by various researchers that powdered activated carbon be used for this particular type of experiment (5, 6, 7, 8, 9). The advantage of using powdered activated carbon was that equilibrium would be reached in a much shorter time than with granular activated carbon. Thus, changes in the wastewater due to biological growth would be minimized.

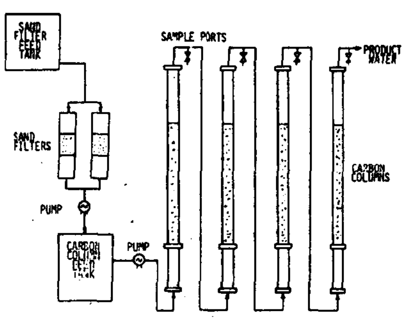

Figure 5 — Sand filter and granular carbon column test system.

The results of the adsorption isotherm tests were evaluated using the Freundlich isotherm:

$$X/M = KC^{1/n} \tag{1}$$

where X = weight of impurity removed at equilibrium

M = weight of carbon used to remove X amount of impurity

C = concentration of impurity remaining at equilibrium

K,n = system constants

Plotting X/M versus C on log-log paper produces a straight line. The equation of this line is the log form of the previous equation.

$$\log X/M = \frac{1}{n} \log C + \log K \tag{2}$$

The constants n and K can then be evaluated from the straight line. The slope of the line is 1/n and K is the intercept. The continuous flow column tests were performed by passing wastewater through a series of four packed granular activated carbon beds, as shown in Figure 6, at a constant rate. The TOC, suspended solids and headloss were monitored for each column.

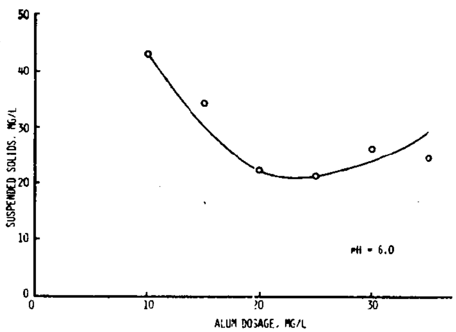

Figure 6 — Residual suspended solids versus alum dosage.

RESULTS AND DISCUSSION

Optimum Aluminum Sulfate Dosage and Effect of pH

The determination of optimum alum dosage and optimum pH was done in a series of experimental runs. The first run tested a range of alum dosages at a pH of 6.0. This pH was chosen because it was within the range in which aluminum salts are known to coagulate well (10,11). The best alum dosage from this run was then tested over the pH range of 4.0 to 7.0 to find the best pH value for coagulation of the particular wastewater being considered. Figure 6 shows the results of testing for the optimum alum dosage on a typical waste sample. The optimum alum dosage varied from sample to sample but remained in the range of 15 to 30 mg/l for chiller overflow, 200-250 mg/l for Scalder overflow and 80-120 mg/l for total plant wastewater. These alum dosages are stated as $Al_2(SO_4)_3 \cdot 18H_2O$. There did not appear to be a relationship from sample to sample between suspended solids concentration and the optimum alum dosage. For example, two samples of chiller overflow with suspended solids concentrations of 60 mg/l and 132 mg/l respectively both had optimum alum dosages of 20 mg/l. A possible explanation for this is that the chiller water studied was a mixture of nonhomogeneous particles differing in composition and size from sample to sample. A given dosage of alum may have destabilized the different particles to different extents depending on their characteristics. Thus prediction of the optimum alum dosage from a parameter such as suspended solids may not be possible.

The effect of varying the pH while using the optimum alum dosage described above is shown in Figure 7. This curve is representative of the results obtained with all the wastewater samples. The optimum pH was judged to be 6.0 or slightly less for chiller overflow, 6.0 for scalder overflow, and 6.4 for total plant effluent.

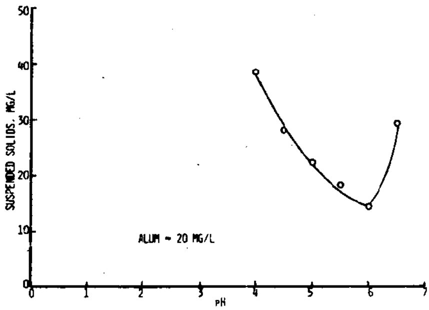

Figure 7 — Residual suspended solids versus pH.

Experimentation With Polymers

A total of 14 different synthetic polymers or polyelectrolytes were tested to determine their optimum dosage and relative effectiveness. Tests were also conducted to determine whether or not varying the length of time between alum and polymer addition affected the results. Table I lists those polymers used and identifies them as to whether they are cationic, anionic or nonionic.

TABLE I

LIST OF POLYMERS TESTED

Dow A-22	Anionic	Dow Chemical Company Midland, Michigan
Dow A-23	Anionic	
Dow N-11	Nonionic	
Dow N-12	Nonionic	
Dow N-17	Nonionic	
Dow N-20	Nonionic	
Dow N-31	Cationic	
Dow N-41	Cationic	
Calgon WT-2640	Cationic	Calgon Corporation Pittsburg, Pennsylvania
Calgon WT-2870	Cationic	
Calgon WT-2690	Nonionic	
Calgon WT-2700	Anionic	
Calgon WT-3000	Anionic	
Magnafloc 836-A	Anionic	American Cyanamid Stamford, Connecticut

The results of testing to find the optimum dosages for each polymer at the optimum alum dosage and pH for chiller overflow are shown in Table II. Similar results were obtained for scalder overflow and total plant effluent. Table II shows that no single polymer type could be classified as yielding the best results under all conditions. In the preliminary testing the anionic polymers Magnafloc 836A and Calgon WT-2700 produced good results, but the anionic polymers Calgon WT-3000 and Dow A-22 and A-23 gave only fair results. In the cationic category Dow C-31 was judged good, Calgon WT-2640 was judged fair to good and Dow C-41 was judged fair along with Calgon WT-2870. The nonionic polymers Dow N-12 and N-20 both gave fair to good results, while Dow N-17 gave only fair results.