INNOVATIVE TECHNOLOGIES FOR WASTEWATER TREATMENT IN ONTARIO, CANADA.

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INTRODUCTION

The Province of Ontario located in the Dominion of Canada occupies an area of approximately 413,000 square miles (1.07 million square kilometres) and has a population of approximately 9.6 million. on an area basis Ontario accounts for 11 per cent of Canada, but by total population represents 37 per cent of Canada.

From the heavily industrialized areas of the north shore of the worlds largest fresh water inland waterways, the Province spreads north through an area consisting of thousands of inland fresh water lakes situated in the Canadian shield.

Davey et al (1985) has reported extensively on the development of water pollution control in Ontario. Up until the late 1960's and early 1970's, industrial development and corresponding population growth was occurring without significant attention paid to the natural fresh water ecosystem. With the formation of the Ontario Water Resources Commission in 1956, the Province started into a new era of environmental management. Initially the emphasis was on providing' adequate conventional sewage treatment for major metropolitan areas, concentrating on the removal of suspended solids and BOD.. However, as the Great Lakes began to succumb to eutrophication as a result of excessive phosphorus loading, technology was put in place for chemical treatment of phosphorus at most major metropolitan sewage treatment facilities.

In 1972 the Ontario Water Resources Commission officially became the Ontario Ministry of the Environment, and through a successive period of restructuring programs the new Ministry (MOE) developed into an extensive regulatory agency based on five major regional areas.

Guidelines for the design of Ontario sewage treatment facilities are outlined in a document entitled "Guidelines for Design, Wastewater Treatment Facilities, in the Province of Ontario" (MOE, 1980). These guidelines represent the minimum standards that must be followed for the design and operation of wastewater treatment facilities if no individual studies are carried out for the design. This often leads to over design of the treatment plant.

Sewage treatment in the Province of Ontario is currently undergoing its third major evolutionary program as a result of the introduction of the new Ontario MISA program (Municipal Industrial Strategy for Abatement).The new MISA program has been introduced in Ontario in response to increased concern for environmental protection, and in particular the need to restrict the discharge of trace organic and inorganic compounds to municipal sewer systems.

TECHNOLOGIES IN PRACTICE

The effluent requirements for sewage treatment facilities in the Province of Ontario vary widely, and in accordance with the receiving water capacities available in the Province. Distinct from the guidelines for the design and operation of sewage treatment facilities in Ontario, the Ontario Ministry of the Environment has implemented policy guidelines for effluent criteria at sewage treatment facilities, referred to as our "Blue Book" standards (MOE 1984).' In specific environmentally sensitive areas proponents of new or expanded sewage treatment facilities are required to undertake an assimilative capacity evaluation to establish actual effluent criteria prior to design and construction of the facilities.

For the major metropolitan sewage treatment facilities located along the shores of Lake Ontario, the primary emphasis has been on the control of suspended solids, total phosphorus and organic carbon measured as BOD Under the new MISA program the control of industrial contaminants is being practised by the treatment and removal of these contaminants,at the source. Typically, major regional facilities on Lake Ontario are required to design for an effluent criteria of 15 mg/L total BOD and 1 mg/L, total phosphorus. Without a requirement for ammonia nitrogen these facilities generally discharge in the range of 15 mg/L ammonia nitrogen, however, in some instances the control of ammonia nitrogen is now being practised at regional facilities discharging into the Great Lakes. In the more restrictive areas of the Province the effluent criteria can be as restrictive as 5 mg/L suspended solids and BOD less than 0.5 mg/L total phosphorus, less than 2 mg/L ammonia nitrogen and a non-detectable chlorine residual.

Ontario sewage treatment facilities have historically been designed and operated to provide for adequate sewage treatment for the average daily dry weather flow. In the mid-1970's regulations began to change to ensure that facilities were designed to handle, not only the average flows, but also peak wet weather flows associated with storm events and the annual snow melt experienced in March and April of each year. Historically excess storm flows were treated by bypassing the sensitive biological portions of the plant providing only chlorination to the bypass flows.

Typical sewage treatment practices in place in the Province of Ontario consist of standard primary treatment, the activated sludge process, alum or ferric chloride precipitation for phosphorus removal, followed by effluent chlorination prior to discharge to the receiving stream. Recently, fixed film processes for biological treatment and/or physical-chemical treatment as an alternative to biological treatment have been utilized after extensive pilot testing.

ALTERNATIVES TO THE REGULATIONS

With the disappearance of the extensive provincial funding provided in the late 1960's, through the 1970's, many major municipalities began to look more closely at the design and operation of their large municipal sewage treatment facilities. The first major regional facilities constructed in the mid to late 1960's were beginning to show signs of wear and tear and with the onset of the 198018 housing boom most of the 1960's facilities were requiring extensive modification and/or expansion. The tightening of the effluent criteria and introduction of the new MISA program put further restrictions on the ability of the municipalities to economically provide adequate sewage treatment using current design guidelines and regulations.

Historically sewage treatment facilities in the Province of Ontario have been based on MOE design criteria without any up front knowledge of sewage strength or industrial inputs. When effluent criteria was not being met the first step generally was to expand the treatment facility, without any rational investigation. Treatment facilities were generally expanded using the mirror image approach, or reconstruction of all unit processes within the treatment facility. Very little, if any thought was ever given to expanding only the unit processes that required expansion.

The approach used by our group is nothing more than common sense. The general sewage treatment plant is a living biological system, so we do not expect it to operate any differently that any other biological system. It needs a buffered balanced diet, the right time to digest its food and an adequate means of disposing of its own waste. Failure to accommodate any one of these essential requirements will result in failure of the system. Designing facilities on the basis of "bigger is better" is one of the surest ways to design and construct an inadequate waste treatment facility.

CASE STUDIES

During the last decade, Pollutech Environmental Limited has been involved in a number of process investigations for biological sewage treatment processes, ranging in size from a 100,000 gallons a day to those capable of treating in excess of 100,000,000 gallons per day. Although the ultimate process used to treat the sewage may differ widely, generally as a result of effluent requirements, the same basic principle for design is utilized. The basic steps required are as follows:

1. Establish the required effluent criteria for the facility, either on the basis of a specific assimilative capacity study or general standards.
2. Establish the quantity and quality of sewage expected of the facility giving due consideration to seasonable fluctuation, wet weather flows, existing or future industrial inputs, and proposed changes to the sewage collection system. A thorough field study including adequate flow measurement and composite sampling is a definite requirement to achieve this goal.
3. Carry out preliminary laboratory studies to evaluate whether biological, physical, chemical or combinations of treatment are required to meet the effluent criteria,,making special note of any items such as influent toxicity, high oxygen demand or development of unstable biological populations.
4. Establish the preferred unit processes to make up the treatment facility and confirm specific design requirements via pilot scale treatability studies. Where technical difficulties or economics dictate, compare alternative technologies with side by side pilot scale evaluations.

Where guidelines are used and approximations are made the costs of additional facilities will generally far exceed any additional costs required for laboratory and pilot scale testing. We have utilized this approach at several installations and a summary of these follows.

<u>Niagara Falls WPCP</u>

The Regional Municipality of Niagara implemented a program in the early 1980's that called for a cooperative approach to sewage treatment between the Region and numerous wineries and food based industries. Pollutech was retained by the Region to conduct a review of alternative technologies which could provide the degree of secondary treatment required.

A detailed evaluation of physical-chemical treatment versus the conventional activated sludge or rotating biological contactor (RBC) biological processes, clearly showed that the Rotating Biological Contractor was the preferred alternative for this installation. The soluble organic strength of the sewage was too much for physical-chemical treatment and the wide fluctuation in different winery and food processing waste caused excessive filamentous growth and sludge bulking for a conventional activated sludge process. The fixed film concept of the RBC system allowed for adequate biological treatment without having to worry about the problems associated with filamentous growth.

The major obstacle to implementing this process in the Province of Ontario was that it was the first major regional sized sewage treatment facility incorporating the RBC technology. Standard design guidelines from the MOE called for RBC facilities to be designed on the basis of 1 lb BOD/1000 ft^2 of media, however pilot scale testing revealed that the process operated with average loading levels of 2.5 lb/1000 ft^2 with peak loadings in excess of 3.5 lb/1000 ft^2. Since this did not conform with MOE design guidelines, an extensive pilot plant testing program had to be utilized to substantiate the acceptability of the process. The RBC pilot plant was operated side by side to a conventional activated sludge pilot plant and a series of smaller scale bench scale activated sludge units were used to evaluate a wide range in hydraulic retention times. Physical and chemical pretreatment was used during the heavy wine and food processing season to reduce the organic load to the biological portion of the plant.

Despite the continued scepticism of the regulatory officials, this facility has provided effluent quality within the guidelines since conception, and continues to do so during even the heaviest of the loading from the wine industry. Constructing this facility using RBC technology and using much higher loading rates than in the design guidelines has resulted in significant capital and operating costs savings, whilst still providing the necessary effluent quality. Without the scientific work carried out prior to the construction of the facilities it would not have been possible to build this plant in the Province of Ontario.

Milton, WPCP

This small treatment facility in the Regional Municipality of Halton serving a population of some 30,000 people is situated approximately 20 km inland from the Great Lakes, and as such its effluent discharges into a small stream draining the watershed to Lake Ontario. Due to the environmentally sensitive nature of the receiving stream, an assimilative capacity is required in the Province of Ontario to establish the acceptable effluent criteria. Specific concerns established by the regulatory officials require that the plant produce an effluent at less than 5 mg/L suspended solids and BOD less than 0.5 mg/L phosphorus, 2 mg/L ammonia nitrogen and less than 0.5 mg/L chlorine. The plant incorporates primary settling, activated sludge treatment for biological carbon oxidation and nitrification in a single stage. Mixed media filtration followed by final effluent chlorination and de-chlorination is practised.

Extensive laboratory scale testing was utilized to set the critical parameters for biological nitrification due to the sub-zero temperatures experienced through the months of November to March of each winter. The single stage nitrification facility operated in excess of 90 per cent efficiency with an HRT of 8-12 hours, an SRT of 10 days, and a total oxygen supply of 1.5 lb oxygen per lb of BOD_5. The final design criteria were accepted by the Ministry of the Environment, only on the condition that once the full scale facility was constructed a detailed plant audit had to be completed to verify the acceptability of the design. This study was completed in the early 1980's and the plant was found to be functioning equal to or better than that predicted by the laboratory scale treatability studies.

As a result of stream improvements brought about by the enhanced treatment facilities along with channelization and flow augmentation in the stream, the plant designed and constructed in the late 1970's has been determined to be most likely capable of providing more treatment than in the initial design, despite the strict criteria imposed. Our firm, in conjunction with the design firm of R.V. Anderson Associates Limited, Toronto, Ontario, established the procedures by which an additional 20% treatment can be provided for this small community without additional capital construction programs. Only through the process of a detailed review of the assimilative capacity of the receiving stream and an operating audit of the treatment facilities themselves will the Ontario Ministry of the Environment allow for increased utilization of this facility.

The Milton facility is unique in that it clearly demonstrates that a properly designed and well operated biological single sludge nitrification facility can provide for an effluent quality that far exceeds the criteria estimated from textbook evaluations of such a facility. Operation of the plant under the optimum conditions is the key to the success of this facility.

Welland, Port Dalhousie and Carleton Place, WPCP

A great emphasis is now being placed on projects in the Province of Ontario that deal with sewage treatment facilities, handling higher than normal peak flows as a result of either high infiltration into leaking sewers, or a collection of combined sanitary/storm sewage from older collection systems.

The first phases of these major facilities, built in the 1960's under the auspices of the Ontario Water Resources Commission, have large biological plants, which were supposedly capable of handling the peak wet weather flows. Fiscal restraint in the 1980's meant the Regional Municipalities were no longer able to build these large facilities solely for the purpose of handling peak wet weather flows. Test results collected from these plants during their operation in the 1970's and early 1980's also suggested that the technology of building big biological treatment plants was not an effective way to meet the stringent effluent criteria required in the Province of Ontario.

Using the process of laboratory and pilot scale testing to document the acceptability of alternative technologies, our group at Pollutech has been able to demonstrate that a much better level of treatment can be achieved using biological treatment as the core treatment for the dry weather flows with physical-chemical treatment being used to handle extraneous flows during wet weather periods. Although the specifics of the three plants categorized in this section differ, they generally have primary treatment facilities which can be subdivided into those primary facilities providing physical settling only And the primary facilities providing physical-chemical treatment by way of rapid mix, flocculation and settling in conjunction with biological treatment. During dry weather flows all of the sewage receives conventional primary treatment followed by secondary biological treatment, effluent chlorination and discharge. During storm events the physical-chemical processes are activated for a portion of the primary clarifiers and the physical-chemical effluent is then bypassed around the biological portion of the plant to be blended with the secondary biological effluent prior to chlorination and discharge. The combined biological and physical-chemical effluent is of superior quality to that which could be achieved through the construction and operation of a large biological process.

The Welland facility also includes biological nitrification, and effluent filtration as part of the. combined treatment processes. In this instance there was a specific need for controlled hydraulic retention times in the nitrification basins that resulted in the process selected. in the case of Carleton Place, where nitrification was not a requirement, it was the extended wet weather flow periods resulting from groundwater infiltration that resulted in the selection of the physical-chemical treatment to supplement the biological treatment. At the Port Dalhousie facility it was the economics of the system related to the capacity of the existing biological treatment plant that resulted in the selection of physical-chemical treatment to supplement the biological processes during storm flow conditions. In each case, although the process selected is very similar, the reason for selecting the process varies significantly.

Since conventional technology in Ontario normally utilized the biological process for secondary treatment there was some scepticism from the regulatory officials in allowing for facilities that used combined physical-chemical and biological treatment to achieve the effluent conditions required. Again we relied on the use of extensive laboratory, pilot, and full scale treatability testing to document the acceptability of the processes and the ability to conform to the effluent regulations.

Woodward Avenue, WPCP

In the case of the Regional Municipality of Hamilton/Wentworth Woodward Avenue Sewage Treatment Plant, an extensive period of laboratory and full scale testing was used to redefine the treatment process required to achieve a suitable effluent criteria for a conventional activated sludge facility. The major problem with this facility was that it had been based on the Ontario Ministry of the Environment design guidelines, calling for biological aeration times far in excess of that required to provide adequate treatment. As a result the plant produced effluent quality of 70 mg/L solids and 40 mg/L BOD_5. When the biological process was found to be inadequate at providing effective treatment, the immediate reaction was to increase the size of the aeration tanks and corresponding ancillary equipment without any study of the true cause of the problem. A limited amount of laboratory scale testing quickly and economically identified the cause of the problem. Reported problems of complex industrial waste input and/or dumping of toxic waste were found to be unsubstantiated, and to the contrary the process design was the problem at the installation.

Detailed process testing revealed that the excess aeration tank capacity resulted in a high degree of nitrification. The development of pin floc, often associated with nitrification facilities could not be handled in the conventional secondary clarification facilities provided. With the improper match of the secondary clarification facilities, a large portion of the biological solids was being lost in the plant effluent, particularly during periods of increased hydraulic flow. Optimization of the biological process, to limit the degree of nitrification, resulted in an improved biological floc, and a corresponding ability to maintain the solids within the treatment facility.

The initial study for the control of the biological processes at the Woodward Avenue plant encompassed a period of not more than 10 or 12 weeks, however, our work at the plant continued over a 3 year period, due to the complexities of a number of other items within the facility, including dissolved air floatation, sludge filtration, anaerobic digestion, sludge incineration and primary plant problems. As a result of the extensive evaluation carried out at the Woodward Avenue plant it was determined that construction activities costing in excess of 10 million dollars had been unwarranted, and that a plant rated for 60 IMGPD was actually capable of providing treatment in excess of 120 IMGPD. In addition, planned construction activities were found not to be warranted, and for the plant operating under its current mode over $1,000,000 per year in extraneous operating costs could be eliminated from the budget. As can be anticipated, the financial savings from the minimal amount of process work carried out were significant.

WHAT THE FUTURE HOLDS

The concept of process design prior to civil and mechanical design is gaining a foothold in the Province of Ontario. With the onset of the new MISA guidelines in the 1990's, there is an increasing willingness of the major municipalities and operating authorities to look at alternative technologies. Extensive research and development work on conventional sewage treatment processes is now being readily accepted by the civil engineering firms as the old guard sanitary engineers are slowing being replaced by the engineer/scientist. There is no doubt that the move towards the acceptance of the new technology is being supported by the tighter fiscal policies in place, as well as the onset of new and improved methods for detection of low levels of trace organics. Although we have come a long way in a very short time, there is still a considerable amount of work to be carried out.

We realize from our review of the literature that extensive use is being made in other countries of technologies using fixed film aerobic or anaerobic processes for the treatment of domestic or mixed domestic industrial waste. There are no projects in place in the Province of Ontario, that use fixed film or anaerobic processes or combinations thereof, at municipal treatment facilities. Where this technology has been introduced is primarily at the industrial level where a detailed evaluation of the cost benefits has clearly supported the need for these alternative technologies. Although extensive research is being carried out on the use of fixed film anaerobic digesters or alternative methods for stirred tank anaerobic digestion, there is very little progress towards implementing any of this technology in the Province of Ontario. Only through continued pilot scale demonstrations of the new technologies, and perhaps With the construction of demonstration facilities in Ontario will these technologies begin to develop.

As Canadians we are somewhat unique in the field of water and waste water treatment, in that we inhabit a vast area of land with a small amount of people relative to many of the European communities, or third world countries. As very strong environmentalists in general, however, we take a proactive approach to protection of the environment and management of our natural resources. Due to the expanse of our natural freshwater inland waterways, we are perhaps not as fast as we should have been in developing and implementing "state-of-the-art" sewage treatment technologies, but during the last 15 years we have moved a long way towards implementing new technologies to achieve the best in wastewater treatment. Unlike many of the third world countries that perhaps require this degree of treatment, for far more important health related reasons than environmentally related reasons, we are fortunate that we have the financial base to support these projects.

As much as we continue to offer our support to others and developing nations through financial programs, it is important that we continue to offer our support through the advancement of technology for water and wastewater treatment. Although a number of the technologies now being introduced in the Province of Ontario may be based on the concept of getting the best treatment for the least number of dollars, the same type of philosophy can be used for the integration of treatment technologies in other countries. What is lacking is the ability to provide the up-front laboratory and/or pilot scale work necessary to implement these technologies. It is important that we as Canadians realize that our support in the third world nations must include not only the financial support to construct adequate water and sewage treatment facilities, but also to implement the correct approach for the selection of the best technology for any one area. This of course requires close cooperation between all the parties involved.

On a final noted, we as Canadians have never been too proud to look at the results achieved by those in other nations in the advancement of technology. Scientists and engineers from other countries, must be encouraged to promote their new technologies and the procedures by which they implement these technologies in their country. For this technical exchange to work properly this must not only include an exchange of technical information at the equipment suppliers level, but also a regulatory exchange of information between the various bodies responsible for the financing, regulation and control of water and wastewater treatment facilities. In as much as standardization of analytical methods has provided a common base for evaluating test results, development of standardized protocols for new technologies will lead to the increased acceptability of technically sound treatment processes and early termination of processes which are based on an abundance of fancy wording with very little technical merit.

REFERENCES

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