Biological Treatment Solves Low Temperature Wastewater Problems

by Camille Charette
and
Jean Herbineaux
Reichhold Chemicals Limited

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Diversity is the keyword at Reichhold Chemicals Limited's Quebec plant. A multitude of resins, including phenolics, urea-formaldehyde, alkyds and polyesters, are manufactured there, in addition to formaldehyde by the Formax continuous process. But with diversity comes special wastewater disposal problems.

In a batch process the same reactor is used to produce a wide range of different products, and it is necessary to clean the reactor between each group of products. At the same time there are many chemical transfers to be made, such as the charging of the reactor, the drumming operation or the filling of tank-trucks and tank-wagons. These steps necessitate the cleaning of piping, pumps and tanks after each transfer. The cleaning operations result in contaminated wastewater that must be disposed of.

In the production of phenolic resins, there is a distillation step which gives a distillate containing from five to eight percent aqueous phenolic solution. This solution is partly recycled by concentration but the balance, containing important quantities of phenols, must be disposed of.

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For several years all liquid wastes were dumped down the sewer. During the early 1960s efforts were made to reduce this contamination problem, but the results were not very positive.

In 1969, serious studies were undertaken to remedy the situation once and for all. During 1970, an incinerator was installed to dispose of the phenolic distillates. This equipment did not solve the entire problem, but it removed from our wastewaters a major part of our most toxic contaminant, the phenol.

At the same time, in a pilot plant, we studied the possibility of using a biological process for the treatment of our wastewaters. The results were conclusive and we received the go-ahead to construct such a system.

The Solutions — First Stage

After several delays in the delivery of equipment, we started our first biological system in the fall of 1972. We had rerouted all plant effluents to a central point and we no longer had any direct discharge to the municipal sewer system, except for sanitary wastes.

The system consisted of two lagoons. The first one was an equalization basin, 110 ft. wide by 160 ft. long by 8 ft. deep. A 10 hp surface aerator performed the mixing. This basin had a nominal retention time of two days.

In the second basin, biological treatment was to take place. The width of the basin was 136 ft., the length 242 ft. and the depth 8 ft. Two surface aerators of 25 hp each were employed to supply the required oxygen. From there, the treated effluent was dischared to the municipal sewer. This system functioned very well, as long as the temperature was not too low. In winter, however, biological activity was nil.

The Solutions — Second Stage

It must be noted that the above mentioned treatment system did not have a clarifier, and we had learned that it would be mandatory to recycle our biomass if we wanted to improve the efficiency of treatment.

After a thorough investigation, we decided to undertake a pilot plant study program with Greey Mixing Equipment Limited, Toronto, Ontario, a unit of General Signal, making use of their Lightnin Treatment System with integral clarifier.

During the course of the pilot study, which lasted a few months,

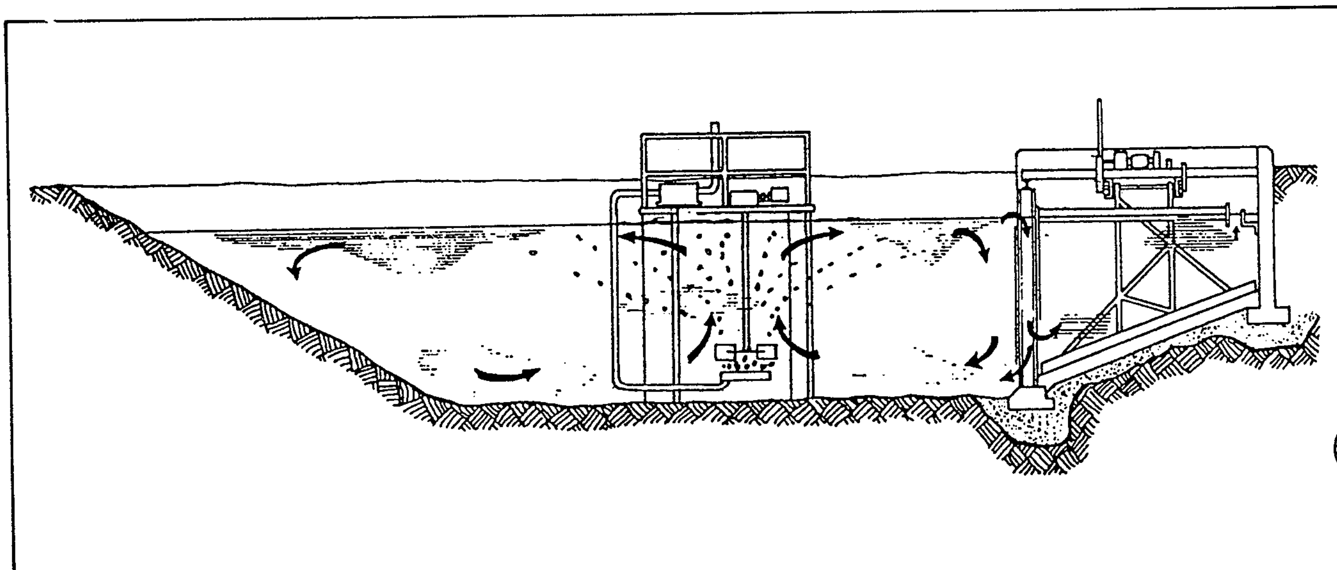

Figure 1. Earthen Basin with Integral Clarifier.

the pilot plant was operated at low temperatures in the range of two to three degrees. All variables were considered and we even created the effect of shock loading by adding pure phenol and formaldehyde.

In the autumn of 1974, we received sufficient data from the pilot study to be convinced that the proposed system with integral clarifier could be employed successfully. The reduction of BOD exceeded 94 percent, and the elimination of phenol plus other contaminants was total.

We wish to emphasize that at this time (1969) we had no knowledge or expertise in the area of waste treatment. By 1974, we had invested a considerable amount of money and we could not afford to start over. Therefore, we had to consider ways of modifying the existing system to improve efficiency and to maintain further investments at a minimum level.

The surface area of our existing lagoons were too great and the depth was inadequate. To modify these two dimensions would have been costly and we wanted to maintain them, if it was possible. Therefore, the results of the above mentioned study program were accepted and we proceeded with the necessary changes to the original system.

The three surface aerators were converted to submerged turbine units. In the equalization basin the unit was increased from 10 hp to 25 hp. In the aeration cell the two 25 hp surface aerators were converted to 40 hp submerged turbine units.

In addition, two 50 hp blowers were installed at the aeration cell for injection of air below the submerged turbines through distributors.

Finally, along the side, at the outlet end of the original aerated lagoon, we installed the integral clarifier. Therefore, we installed an automatic recirculation system for the biomass.

The principle of operation of this system is:

• The submerged turbine aerators in the aeration cell disperse air for oxygen transfer and develop a high level of mixing in the basin. This high level of mixing allows the system to operate at the maximum MLSS ratio of less than 0.1 and providing sufficient biomass to assimilate shocks and upsets.

• Surface velocity developed by the aerators across the top of the aeration cell provides downward flow through the recirculation baffles at rates from five to ten times the plant flow rate. The sludge scraper mechanism, which travels the full length of the clarifier, transfers the settled sludge to the return ports in the common wall where it is recycled automatically by the high flow rate mentioned above.

• In the aeration cell, with complete mixing, the returning biomass is instantly resuspended.

• The overflow weir is located along the length of the clarifier on the opposite wall. From the overflow weir the treated wastewater flows to the municipal sewer system at a quality almost equal to potable water and far superior to the water in the river.

Because of delays in equipment delivery, it was not until December, 1975, that we were able to undertake modifications to the original treatment plant which were completed in February, 1976. It was the middle of winter, but we attempted to start biological activity by seeding the system with sludge from a municipal treatment plant. This attempt was not successful.

During the first week of April, however, biological activity began and it has not stopped since.

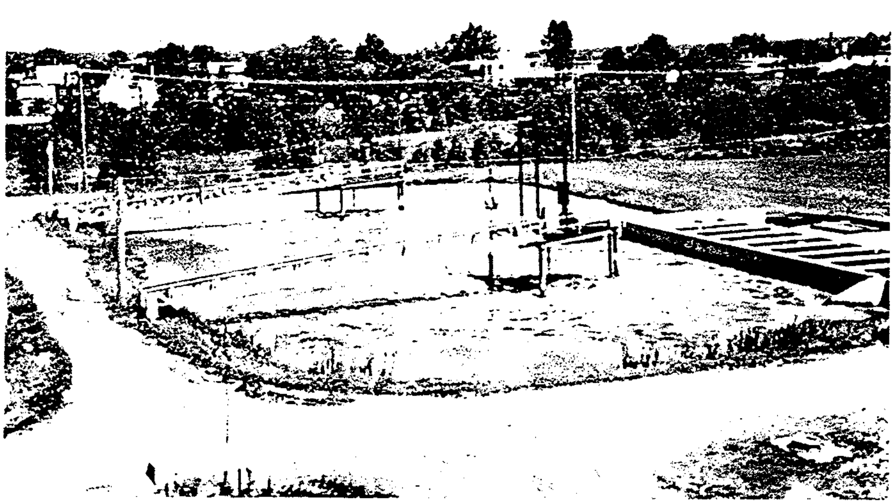

Photo illustrates the Lightnin Treatment System at Reichhold Chemical's Quebec plant.

Instrumentation

From the beginning, we were carrying out analysis at different points in the original system to determine pH, phenol, phosphate, formaldehyde, and COD concentrations.

However, because of a lack of analytical data and with our very limited experience, it was not possible to adequately control the system. The frequency of sampling was increased, but this was still far from adequate.

We employed a technician full time to make analyses. We were unable to improve our control with conventional methods, even by adding more personnel.

Consequently, we considered the possibility of instrumentation. We visited several laboratories, including the government laboratory operated by the Services de Protection de l'Environment. Finally, at the end of 1973, we decided to purchase a Technicon Analyzer which was placed in operation during the spring of 1974.

This equipment permitted us to accumulate a considerable amount of data and allowed the study of the phenomenon of biochemical treatment itself.

From the moment that the Lightnin Treatment System was installed, our desire has been to develop the concept of control by instrumentation and we have designed a sampling system which provides direct readings in our plant laboratory from five locations. These samples are injected into an analyzer which can analyze simultaneously three different parameters from each sample. A second part of the analyzer has been developed to make continuous and automatic analyses of phenol at the inlet to the treatment plant.

In addition, an alarm system is connected to the laboratory to indicate if any mechanical component of the treatment plant or any step in the automatic analyzer is not performing satisfactorily. During weekends, the alarm is transferred electrically to the boiler room. The boiler room operator has only to telephone a technician if an alarm sounds.

Our instrumentation and controls permit the following:

(a) Automatic pH control; (b) Continual and automatic analysis of phenol; (c) Simultaneous analysis of formaldehyde, phosphate and ammonia; (d) In a second step, analysis of COD and nitrites-nitrates; (e) Adjustment of the concentration of phenol entering the treatment system by the addition or reduction of phenolic distillates; and (f) Automatic calibration of the different components of the analyzer.

At the same time we adapted the Auto Analyzer to our needs in the area of waste treatment, we also de-

Table 1
Average Composition of Wastewater*

	Before Treatment	After Treatment
Flow	±250	±250
Phenol	250	0
Formaldehyde	900	4
Ammonia	1-2	0.14
Orthophosphate	2-6	0.4
COD	3000	193 (93.6% reduction)
BOD_5	2400	57 (97.8% reduction)
pH	9-12.5	7.4-8.3

* for a given period

Table 2
Efficiency of Treatment System

	Summer Above 10° C	Winter Below 10° C
Average pH at inlet of system	11.0	9.5
Average pH in aeration cell	8.3	7.4
Buffering action of pH in the system	24 percent	22 percent
Clarifier efficiency	98.0 percent	99.4 percent
Reduction of COD	95.6 percent	94.0 percent
Reduction of BOD_5	98.4 percent	97.7 percent

veloped methods of analysis for our production requirements.

When the treatment system is operating normally, that is without shocks or accidental spills, we require 1½ hours per day to carry out all necessary analyses. The results are recorded on charts and we have only to make the calculations. These calculations can be a bit tiresome and do take up time. Therefore, we hope to proceed with the installation of a mini computer which will permit the calculations and conclusions to be developed automatically.

The Results

All of the above expenditures have not been without benefits. The results we are obtaining are rewarding. We have developed and installed a biological treatment system capable of withstanding our extreme winter temperatures.

During this past winter, we had the opportunity of submitting the system to its first test and all results were conclusive.

During the month of December, we experienced temperatures as low as -28 degrees C. and the temperature in the aeration cell itself dropped to 1 degree C. without any loss of efficiency. All available literature on the subject suggests that below eight degrees C. biological activity would cease but, with our system design, we have proven otherwise.

However, this success has not come by itself. The living microorganisms must be taken care of in order to maintain their effectiveness. pH is a very important control factor in our system. During summer we have maintained an average pH of 8.3 and 7.4 in winter.

With warmer operating temperatures, biological activity is great. This permits us to operate at a high pH level. Conversely, with low temperature, biological activity is slower. If the pH were maintained at the higher level, the microorganisms would become intoxicated before having time to carry out their work.

There is also a direct relationship between pH and the concentration of biomass. The more we lower pH, the higher the development of biomass. This is an additional reason for maintaining a lower pH during cold periods.

The system design itself permits the maintenance of a high biomass and this higher level permits assimilation of shock loads caused by upsets. **Table 1** and **Table 2** indicate characteristics of waste before and after treatment.

At first glance it is suggested that a rate of sludge recycle is higher in winter than in summer. This could be possible but to date we have not accumulated sufficient data on summer operation to confirm this observation.

Exactly what impact have spills or upset had on the system? Last December, after the cleaning of a formaldehyde storage tank, some water accumulated in the vent pipe and froze. Later, when formaldehyde was pumped into the tank the pressure built up and the tank began to leak at three places, leaking 40,000 lb. of 44 percent formaldehyde.

This happened at night and went unnoticed for three to four hours. Our system permits the isolation of high concentration spills and t disposes them at a later date at reduced flow rates. However, before the spill could be isolated, the concentration of formaldehyde entering the aeration cell increased from 500 ppm to 4,700 ppm. At that time the atmospheric temperature was -25 degrees C. and the operating temperature in the aeration cell was +1 degree C.

All of the extreme conditions required for the ultimate test has been created by accident. To our great satisfaction, the shock had no detrimental effect on the treatment system. The biomass concentration in the aeration cell was at 7,900 mg/l before and at 7,300 after the shock, which we consider to be a normal fluctuation. The phenol concentration leaving the treatment plant was at zero and remained there. Formaldehyde concentration was 2.6 before the spill, increased to 3.5 ppm and returned to 2.8 by the following morning. The rate of BOD_5 removal was 98.9 percent before the spill and 98.6 percent after, which we also consider to be a normal fluctuation.

Another upset involving approximately 1,800 lb. of pure phenol caused the concentration at the inlet to the aeration cell to increase from 250 to 600 ppm in a few hours. In this case, there was no reduction of efficiency.

We have demonstrated that our system is as efficient in cold weather as in warm weather. It is also able to adapt itself to a wide range of conditions. The microorganisms can be acclimated to very low temperatures.

Before the cold weather, a fixed volume of mixed liquor took 4 to 5 minutes to pass through the filter paper, while in winter the same test took up to 45 minutes. With the return of warm weather, the filtration time returned to 4 to 5 minutes. It would seem that the micro organisms cover themselves with some substance which increases filtration time by a factor of ten. This indicates that the microorganisms must acclimate themselves to winter, thereby making it impossible to activate a system during winter.

With rising temperatures, we have noted the reverse of this mutation process. The microorganisms became very light and active. For intermittent periods, clarification was abnormal and great quantities of biomass were discharged without affecting the biological activity of the system.

We had to add coagulants to return the operation to normal, which was not necessary in winter.

Conclusions

In 1969, we had set a goal to solve once and for all the problem of contaminated wastewater. We can say that we have achieved that goal. Not only is the Lightnin Treatment System efficient, but we have also developed the necessary instrumentation to control it. ■