Waste Water Recirculation as a Means of River Pollution Abatement

W. W. BLANKENBACH AND W. A. WILLISON[1]

Received for publication April 15, 1968

The Manitoba Sugar Company Limited operates a beet sugar factory in Fort Garry, Manitoba adjacent to the Red River in a suburban area upstream from Metropolitan Winnipeg. Water from the river is available for processing purposes but, because of the heavily populated area through which the river flows, the return of the factory effluent is undesirable though this was tolerated for the first 15 years of operation.

As the city grew the river could not absorb the increasing load of domestic and industrial wastes, and the establishment of a government sponsored commission to control this pollution was inevitable. The Commission was given considerable powers to force both industry and municipalities to conform to standards of quality for effluent discharge, and these powers were later augmented by the formation of a "Metro" system of government for Winnipeg in 1960.

Industry was required to contribute to the cost of sewage treatment in the metropolitan area on the basis of the volume of untreated wastes discharged to the river or public treatment facilities; effluents exceeding set levels of quality were subject to additional surcharges. The Company's sewage charges had exceeded $64,000 per year prior to the installation of the recirculation system, and, therefore, it was under considerable economic as well as public pressure to reduce or eliminate its pollutional load to the river. This posed a formidable problem for, although the factory wastes were similar to those from other beet sugar operations, the soil conditions and extreme climate contributed difficulties not commonly experienced elsewhere.

Climatically, extreme cold can be expected during much of the processing season, and freezing weather is usually continuous after November 1st. Thus, all harvesting must be completed before freeze-up which means that some two-thirds of the beet crop is piled. The cold weather further influences the handling methods because moving beets in rail cars from outside points in temperatures below 10°F is difficult, if not impossible. For that reason, beets grown in more distant areas are railed to the

[1] General Chemist, The British Columbia Sugar Refining Company Limited, Vancouver, B. C., and Manager, The Manitoba Sugar Company Limited, Winnipeg, Manitoba, respectively.

factory during harvest to be unloaded with clamshell buckets into piles. This procedure plus subsequent reloading and transport to the wet hopper causes a great deal of mechanical damage to the beets and provides broken surfaces from which sugar is leached by the flume water. Sugar pick-up by the flume water is also increased if there is any deterioration of the beets in the storage piles, which will occur should "hot spots" develop.

The soil in much of the beet growing area is classified as clay loam, commonly called "gumbo". In wet seasons, large amounts adhere to the beets so that the flume water picks up an enormous load during the transport of beets into the factory and during the washing process.

From the foregoing it can be seen that any treatment system must accommodate dissolved organic matter and suspended solids in unusually large amounts.

Methods and Description

Before describing the recirculation system, it is sufficient to state that pulp press water and lime cake are not discharged; the former is returned to the diffuser and the latter is lagooned. Plans are presently underway to install a semi-dry lime mud handling system.

Formerly, flume water supply was passed through the evaporator and pan condensers prior to being used to transport beets. Since the quality and amounts of water required for the two functions are unrelated, it was obvious that separation of the two streams would simplify the design of a recirculation system.

First, it was established that water from the Red River for condenser injection could be returned to the river without penalty provided levels of contamination were sufficiently low. Since facilities existed for pumping water from the river, no attempt was made to establish a closed recirculating cooling water system.

Knowledge of recirculation systems used by the British Sugar Corporation provided a basis for study while the report presented by S. Force[2] of The Great Western Sugar Company provided further important data. From these, a scheme applicable to Manitoba conditions was worked out and put into operation in 1965.

For fluming, an estimated flow of 5,000,000 imp gal per day would have to be maintained in a closed system, requiring a volume of about 350,000 imp gal to fill a clarifier, surge tank,

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[2] Force, S.L., 1965. The Findlay Flume and condenser water system. J. Am. Soc. Sugarbeet Technol. 13(6): 478-491.

sludge beds, and pipelines and provide detention time for clarification.

Examination of the flume water effluent in the laboratory had indicated that excellent coagulation and sedimentation could be obtained by adding lime to an alkalinity of pH 11.5+. Further tests were made by a clarifier manufacturer in designing a settler that would handle the flume water flow, and an overflow acceptable for transporting and washing beets. This was incorporated into the system, illustrated in Figure 1, consisting of a screening station, clarifier, sludge handling and clarified water supply system.

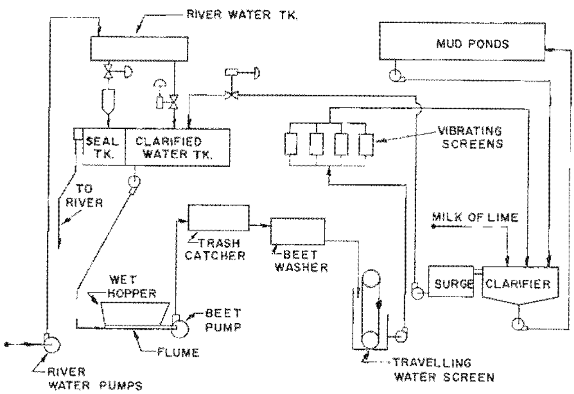

Figure 1.—Flow diagram of flume water system.

The flume water screening station consists of a travelling water screen which gives a primary removal of coarse organic material for the entire flow. In series with this are four 4 × 8 ft vibrating screens with decks of 6 × 6 mesh operating in parallel. The screened water flows to the intake launder of the clarifier where water-slaked milk of lime is added to raise the alkalinity to the desired level (pH 11.5+). The clarifier overflow enters a surge tank and is pumped to the flume water supply tank as required.

Provision has been made to use clarified water in the evaporator condenser to maintain the temperature of the water at a suitable level during extremely cold weather. This has proven to be simple and effective.

The underflow from the clarifier is pumped to a disposal area which is graded to give good drainage to a collection ditch. Sedimentation of the sludge has been rapid and the clear water flows to a pump house to be returned to the clarifier. Under most conditions, this water has a higher clarity than the clarifier overflow.

There has been a tendency to form lime scale in the pump and pipe lines of the return water system from the sludge beds. This has been easily controlled by flushing the pump with muriatic acid at infrequent intervals, and alternating the direction of flow between the outgoing mud line and the return water line every 3 weeks. The scouring action of the soil in the underflow has been sufficient to prevent a build up of scale in the lines.

The sludge collection beds (Figure 2) consist of two adjacent areas 1,360 ft long by 450 ft wide with an average depth of 2 ft. Each area is divided by cross dikes into cells to give one section 440 ft × 450 ft and four sections 230 ft × 450 ft. The two adjacent areas are used in alternate years in order that the collected sludge will have a year or more to stabilize before it is excavated. This cell structure provides better drainage than one large area where low spots allow water to accumulate and become

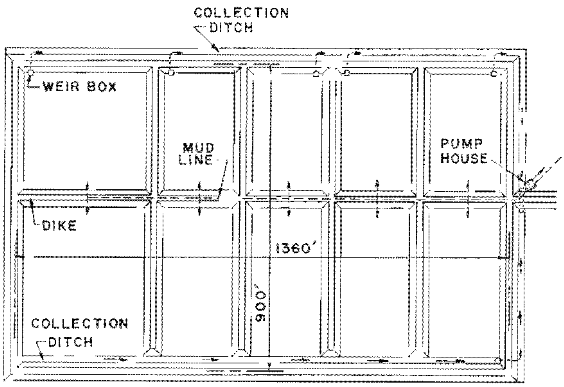

Figure 2.—Mud settling ponds.

septic. An odor problem does not occur where good drainage exists.

The clarified water is used for all fluming operations and in the beet washer. Provision was made for a final spray rinse with fresh water as the beets pass over the roller table between the washer and elevator, but recirculated flume water has been used here without any problems. Thus for all practical purposes, recirculated clarified flume water successfully replaces fresh river water in every way for fluming, washing and rinsing beets.

It may be observed here that recirculation of flume and condenser water has already had a considerable effect on water economy of several factories, and selection of new factory sites no longer depends on the availability of large volumes of fresh water.

Some problems with foam were encountered particularly in the flume and beet washer. However, effective control has been achieved by the use of commercial defoaming agents. Tests carried out during the 1967 campaign show emulsified tallow to be the most effective and economical defoaming agent used to date.

A closed circuit operation requires careful control of any loss or gain in the volume of water contained in the system. Make-up to compensate for loss is relatively easy to regulate by automatic injection of fresh water on low level signal from the flume water supply tank. A gain in volume is a more difficult matter and originally was handled by using clarified water to prepare lime cake slurry for pumping to the lime lagoon. This gave a continuous bleed-out from the system and allowed a corresponding fresh water make-up.

During the two summers following the use of clarified water in the lime slurry, very strong and unpleasant odors developed in the lime pond. While poor drainage undoubtedly contributed to this, the highly contaminated flume water was considered to be a contributing factor. Hence in 1967, fresh water was used for lime cake disposal and any excess of flume water in the clarifying system was run out to some spare land. Due to unusually dry fall weather this was absorbed without difficulty and the effect of this practice in wetter years must wait for future developments.

It should be pointed out that the soil in the Fort Garry area allows little loss by percolation and that precipitation is about equal to the natural evaporation. Thus, there is little hope that any large quantity of the waste water can be disposed of in this manner.

The installed cost of the system including the clarifier, surge tank, two mud ponds and associate pumps, piping and controls, but excluding the travelling water screen and four vibrating water screens amounted to approximately $300,000.

Apart from the cost of providing the facilities and their maintenance, the only continuing item of expense is the lime required to promote flocculation and to raise the alkalinity to prevent fermentation. It has been found that the dosage of lime increases with time and appears to bear a relationship to the increasing concentration of dissolved solids. The lime addition has varied between 1.5 and 4.5 tons of CaO per day; it is obtained from the factory kiln and slaked with water to make milk of lime.

The concentration of dissolved solids in the recirculated water builds up steadily during the first 6 weeks of operation but levels out at about 10,000 ppm of total dissolved solids and 6,000 ppm BOD. The progress in this change in concentration is illustrated in Figure 3.

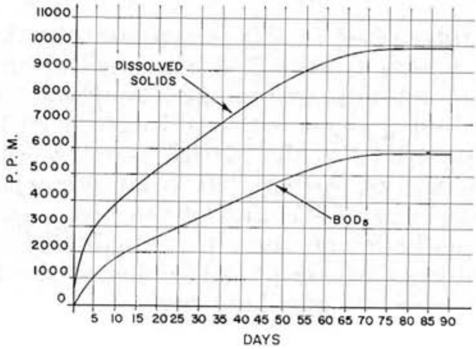

Figure 3.—Build up of dissolved solids and BOD_5 in the recirculated water.

The ultimate dissolved solids concentration in the recirculated flume water is presumed to correspond to an osmotic pressure equivalent to that inside the beet, so that no osmotic pressure differential exists to promote further extraction of the sugarbeet solids.

This situation can arise at dissolved solids concentrations in flume water appreciably below those in the sugarbeet because of the lower molal weights associated with the calcium and hydroxyl ions. The ions nevertheless have the same osmotic pressure as molal amounts of sugars and proteinaceous materials contained in the sugarbeet. As no fermentation occurs in the flume water, due to its high alkalinity, once this equilibrium has been established, the extraction of sugar may be inferred to approach zero.

The effect of this observation on loss of sugar in flume water is illustrated by estimating the quantity released in a non-recirculating system. Based on a usage of 1,700 imp gal of flume water per ton of beets which contains 200 ppm BOD_5 having a sugar equivalent of 1.4 times BOD_5, the quantity of sugar per 1,000 tons of beets is 4,760 lbs. Thus a significant saving of sugar results when the equilibrium point has been reached, which is an observation worthy of some attention.

As far as the sludge beds are concerned, there has been no difficulty with odor, except where water has lodged in small pools which did occur after the 1966 campaign. The collected soil apparently stabilizes within a year, for the first lagoons were partially excavated about 7 months after being deposited, when soil was required for land-fill, and no obnoxious smell was released. It is expected that no problems will arise in disposing of the dry sludge.

Conclusions

The project described in this presentation has been successful in controlling a serious source of river pollution in a heavily populated area. By this action, the Company has been saved substantial disposal charges that would have been levied had the effluent been passed on to the Metro treatment plants. On this basis, the recirculation system has been financially successful. At the same time, one of the aims of the Metro government was to restore the aesthetic and recreational value of the Red River and it is, therefore, a matter of satisfaction to the Company that they have been able to contribute towards this objective.

Acknowledgments

Recognition is given to Mr. A. Penman, Director of the Waste Disposal Division of the Metropolitan Corporation of Greater Winnipeg, for his co-operation and technical advice.

This recirculation system was designed by the staffs of the Manitoba Sugar Co. Ltd. and the B. C. Sugar Refining Co. Ltd., and was based on the work of the B. C. Research Council which investigated the problems of sedimentation and stabilization of flume water.

The assistance of Dr. C. C. Walden of the B. C. Research Council who contributed to the development of this system and the preparation of this paper is gratefully acknowledged.