The 20/20 Effluent Solution for Northern Work Camps – 150 days of technology demonstration.

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INTRODUCTION

The need for work camps in remote areas is prompted by a number of industrial activities such as oil & gas exploration and production, mining, mineral exploration and construction. These work camps usually have to be established quickly, are of a transient nature and are located in remote and environmentally sensitive areas. Often they are established during the winter months. They vary in size, accommodating anywhere from 25 to 400 persons. Utilities such as water and sewerage have to be provided.

It is well documented that wastewater treatment systems located in the north often perform poorly (1). Given and Smith (1), in their extensive evaluation of extended aeration systems in arctic and sub-arctic regions, attributed this to a number of design- and operations-related factors that are summarized as:

Design related problems:

1. ***organic overloading***
2. ***hydraulic overloading & hydraulic surges; and***
3. ***mixing problems specifically associated with oxidation ditches.***

Operations related problems:

1. ***failure to scrape hopper-type clarifier walls***
2. ***failure to maintain sludge returns operative; and***
3. ***underaeration of the mixed liquor.***

In response to these deficiencies, and the need to provide for reliable, cost-effective, high-efficiency wastewater treatment, **TANKS-A-LOT Ltd.** designed a modular, mobile, biologic wastewater treatment plant that is simple, compact, robust, easy to operate and produces a high quality effluent.

This paper concerns the performance evaluation of this easy- to-transport wastewater treatment system. The treatment objective concerned only the reduction of BOD_5 and SS. However, it is recognized that nutrient removal, nitrogen and phosphorus, could be achieved with minor process modifications and adjustments in operation.

The process described, is a flexible, biologic, suspended growth system that can be operated in the Conventional Activated Sludge (CAS) or Extended Aeration (EA) mode. The system is designed to treat pre-treated domestic wastewater. Pre-treatment usually consists of a septic tank or at minimum, screens to protect pumps and ancillary equipment from damage.

Five major study objectives were established:

1. ***devise a methodology for successful process start-up during winter conditions.***
2. ***observe system response under varying hydraulic loading conditions.***
3. ***identify operating parameters to achieve a 20/20 effluent***
4. ***observe sludge settleabilty & sludge production***
5. ***identify operator skill level and time requirements***

This paper reports only on the operating experience for BOD_5 and SS removal under average hydraulic loadings of 2,300 to 3,500 m^3/d.

TREATMENT PLANT DESCRIPTION

A schematic of the process component configuration is shown in **Figure 1.**

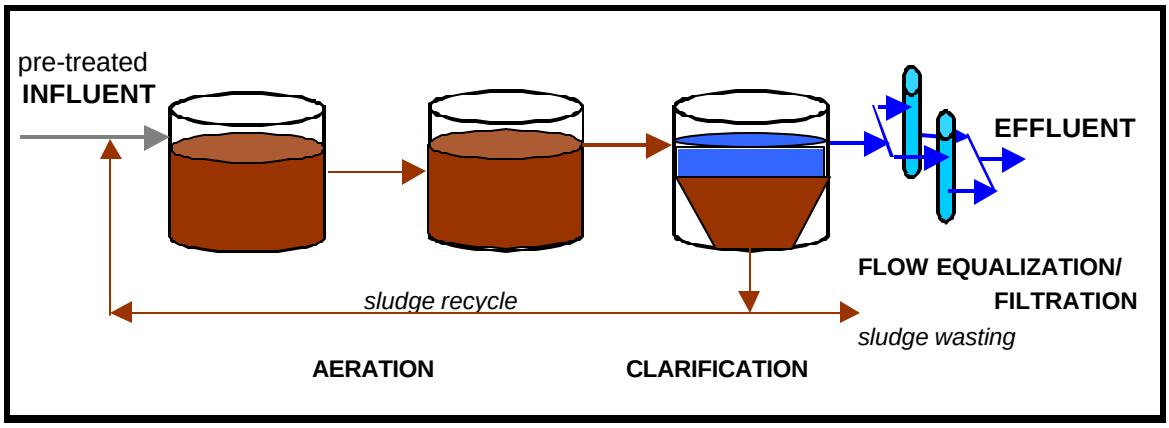

FIGURE 1 Treatment Plant Schematic

Pre-treated influent enters the first aeration tank, passes to the second aeration tank and is followed by gravity clarification. The effluent from the clarifier then flows through two patented Biokinetic™ Units, arranged in parallel. Effluent from the Biokinetic™ Unit, that serves as a flow-equalization device and mechanical filter, is the process effluent.

The complete wastewater treatment plant is housed in a mobile, insulated trailer weighing less than 5,000 kg.

PLANT LOCATION

The mobile wastewater treatment plant was located at the Edmonton Capital Region Clover Bar Wastewater Treatment Plant. The influent to the demonstration plant was pumped from the influent of the Clover Bar degritting unit process.

SAMPLING AND ANALYTICAL PROTOCOL

For remote work camps usual regulatory effluent compliance parameters are BOD_5 and SS. These were determined from grab samples, recorded and correlated to the operating mode of the module.

The usual operating parameters of MLSS, DO, HRT, SRT, temperature, sludge recycle and sludge settleability were monitored.

INFLUENT CHARACTERISTICS

Since the demonstration module would receive normal domestic wastewater at the Edmonton Clover Bar plant, there was a need to establish that the influent wastewater characteristics are similar to those of a pre-treated effluent from a northern work camp.

Calculations, based on experiences recorded in the Cold Climate Delivery Design Manual (2) show that for work camps wastewater strengths average 404 mg/L BOD_5 and 484 mg/L SS.

Pre-treatment.

In many northern work camp situations, this wastewater is pre-treated by a septic tank. By assuming 35 % of the total influent BOD_5 is settleable (3), and 90% of the settleable BOD_5 is removed by settling in the septic tank; that 60 % of the influent SS are settleable (4) and again 90 % of the settleable SS are removed, the characteristics of such a pre-treated wastewater will be in the order of 277 mg/L BOD_5 and 223 mg/L SS, respectively.

This work.

Records of the Clover Bar influent wastewater characteristics were obtained and a total of 130 data over the 5-month demonstration period for influent BOD_5 and SS were analyzed.. These samples were composite samples. The BOD_5 fluctuated between 200 and 400 mg/L, with a few spikes in excess of 500 mg/L. Similarly, the influent SS data varied between 200 and 450 mg/L with a few excursions to more than 500 mg/L.

Over a 5-month period the median BOD_5 was approximately 300 mg/L while the SS was 350 mg/L. In **TABLE 1** these data are summarized and compared to the calculated northern camp wastewater strengths. The data show that the actual influent to the modular wastewater treatment plant was stronger than a pre-treated northern camp wastewater.

TABLE 1 VARIOUS INFLUENT WASTEWATER STRENGTHS

WASTEWATER TYPE		BOD_5	SS	REFERENCE
		mg/L	*mg/L*	
Northern Camps				
	raw	404	484	Calculated
	pre-treated	**277**	**223**	Calculated
Edmonton Clover Bar		**300**	**350**	Actual

WastewaterTemperature.
The average temperature loss going through the module was approximately 3 ^{o}C. This was for a system hydraulic retention time of 18 – 27 hrs, depending on the hydraulic loading rate of the module. The process effluent temperatures varied from 4 to 13 ^{o}C.

MODULE OPERATING MODE

Since one major application target for this mobile treatment plant is remote locations, it was decided that operating a biologic plant in the extended aeration mode satisfies a number of desirable attributes for operating a wastewater treatment plant in remote locations:

1. ***the process is more robust, therefore less prone to process upsets***
2. ***less operator skill is required***
3. ***less operator attention is needed***
4. ***less sludge is generated and needs to be managed.***

PLANT START-UP

The plant was transported to the Edmonton Capital Regional Clover Bar wastewater treatment plant in late October 2001. It took one day to complete all piping and power hook-ups. Wastewater was then pumped to the treatment module at an initial rate of 1,200 US gpd (4.5 m^3/d) from the entrance of Clover Bars' degritting chamber. The influent BOD_5 and SS concentrations averaged about 300 and 350 mg/L, respectively. After approximately three weeks operation the effluent BOD_5 and SS concentrations were 23 and 25 mg/L. During this start-up period, the reactor liquid temperature varied between 13 and 9 ^{o}C. Subsequently, the hydraulic rate was increased to 2,100 US gpd (~ 8 m^3/d). This sudden hydraulic shock coupled with some power outages resulted in a deterioration of the effluent quality. By mid-December a stable effluent quality of less than 20 mg/L BOD_5 and SS was again achieved. It was decided to start analyzing data and record operating experiences beginning with January 1st, 2002.

OPERATIONAL HISTORY

During an initial period from January 1st to January 22nd, the flow varied from 3,000 to 2,800 gpd (11.3 to 10.6 m^3/d). Thereafter, the plant was operated at three constant and distinct hydraulic operating modes:

2,700 US gpd (10.2 m^3/d) from January 22nd to March 17th
3,500 US gpd (13.2 m^3/d) from March 19th to April 16th and
2,300 US gpd (8.7 m^3/d) from April 18th to May 17th

MLSS

It took approximately 6 weeks for a significant biomass to develop. Over the study period the average MLSS concentration varied between 2,000 and 2,700 mg/L.

MLSS Settling

Daily standard 30 minute settling tests indicated that despite a very high SVI, excellent liquid solid separation was obtained.

Sludge Production
By assuming 80% of the sludge is active biomass, it can be calculated that 0.24 kg VSS are produced per kg BOD_5 treated when operating at a daily flow of 3,500 US gpd. On the same basis, 0.13 kg VSS are produced per kg BOD_5 treated for the 2,300 US gpd flow rate.

Sludge production at 3,500 US gpd is almost twice that at the lower flow rate. As well, at 3,500 US gpd the module was no longer operating in the extended aeration mode but in the conventional activated sludge mode.

Sludge Wasting.
During the 28-day period, from March 19th to April 15th, when the hydraulic loading rate was 3,500 US gpd, a total of 3,900 US gallons of sludge were wasted. This represents 32.8 kg of solids. During that period a total of 98,000 US gallons were treated. This amounts to 40 US gallons of sludge wasted per 1,000 US gallons of wastewater treated.

Similarly for the 2,300 US gpd flow rate, the amount of sludge wasted was approximately 29 US gallons per 1,000 US gallons of wastewater treated. The total sludge mass wasted during that 31day period was approximately 15.4 kg.

ANALYTICAL COMPARISON
On three occasions, comparison of BOD_5 and SS data generated by Tanks-A-Lot Ltd. (TAL Lab) and an accredited laboratory was made. The data showed a very close agreement.

BIOKINETIC™ EFFECT
After the sedimentation step the effluent passes through the BIOKINETIC™ units. This unit serves as an additional liquid/solid separator, polishing the effluent by removing additional SS through filtration. The data show that the BIOKINETIC™ units' effluent polishing effect amounts to approximately 5 mg/L SS.

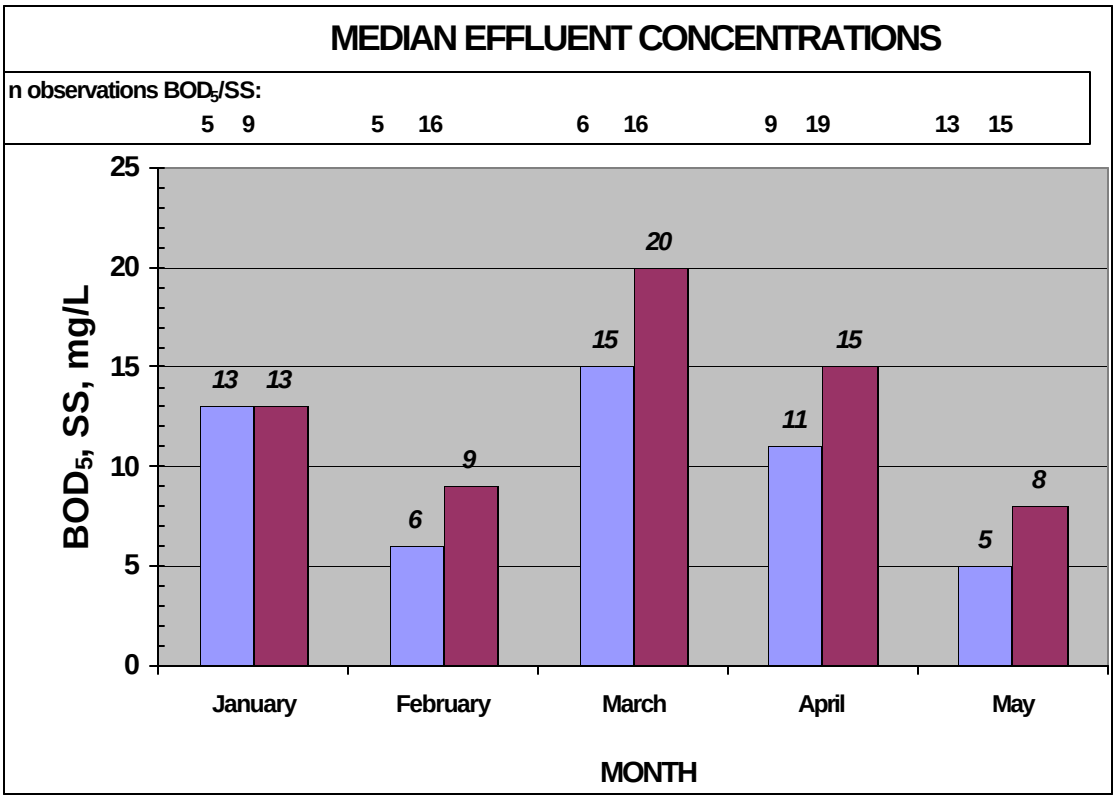

FIGURE 2 Median Effluent BOD_5 and SS concentrations – January – May 2002

EFFLUENT BOD_5 and SS

The median effluent BOD5 and SS concentrations are shown in **FIGURE 2**. During the study period a total of 38 effluent BOD_5 and 75 SS samples were collected.

FIGURE 3 summarizes the wastewater treatment performance of this modular treatment plant. Effluent quality in terms of BOD_5 and SS improves with decreasing hydraulic loading. The median BOD_5/SS concentration at a flow of 3,500 US gpd is 18/20, 9/10 at 2,700 US gpd and 5/7 at 2,300 US gpd.

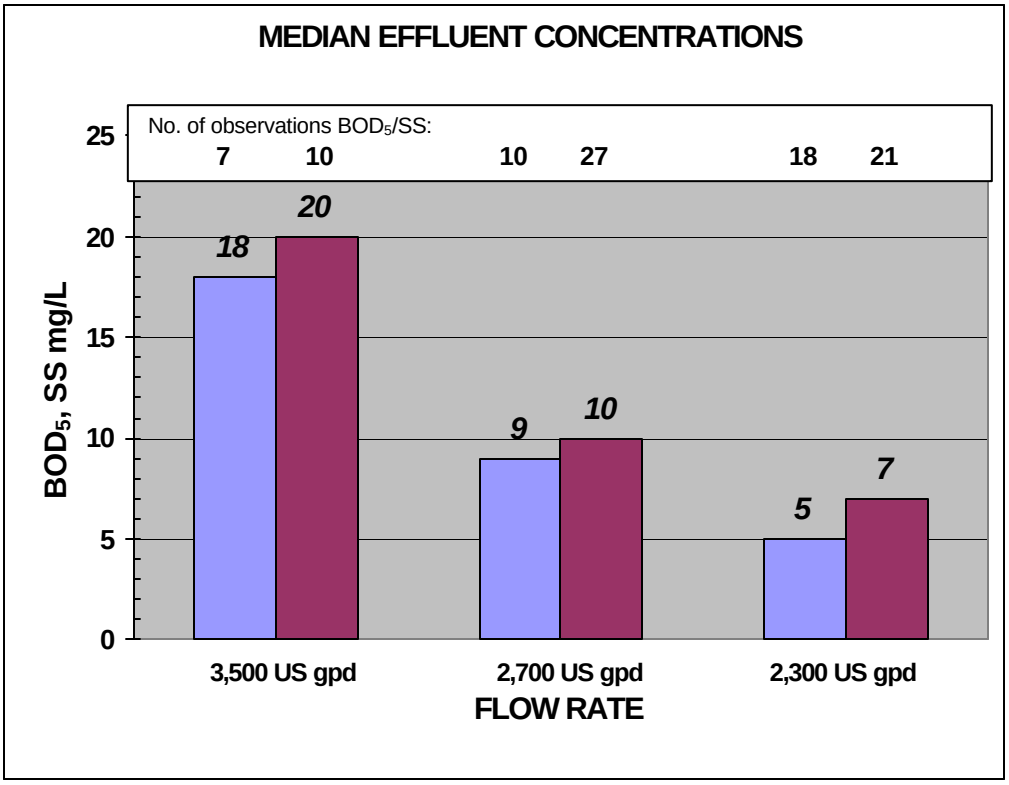

FIGURE 3 Median Effluent Concentrations for Various Flow Rates

SUMMARY AND CONCLUSIONS

The following are the major conclusions:

1. ***The wastewater treatment module was started successfully during the winter months.***
2. ***Within a hydraulic operating envelope of 3,500 to 2,300 US gpd, the module consistently produced a superior effluent that did not exceed a median effluent concentration of 20 mg/L BOD_5 and 20 mg/L SS.***
3. ***For design purposes, the module will produce the following median effluent quality:***

   Less than 10 mg/L BOD_5 & 10 mg/L SS at 2,300 US gpd
   Less than 15 mg/L BOD_5 & 15 mg/L SS at 2,700 US gpd
   Less than 25 mg/L BOD_5 & 25 mg/L SS at 3,500 US gpd
4. ***Sludge production ranged from 0.27 kg SS/kg BOD_5 removed at a hydraulic loading of 3,500 US gpd to 0.16 kg SS/kg BOD_5 removed at a hydraulic loading of 2,300 US gpd.***
5. ***Beyond routine inspections and effluent sampling, the module requires minimal operator attention.***

This paper is a synopsis of a report

Schmidtke, N.W. and K. Zhang, "Achieving a 20/20 Effluent from a Modular, Mobile, Wastewater Treatment Plant for Northern Camps – 150 days of Technology Demonstration", Tanks-A-Lot Limited, Edmonton, Alberta. July 2002.