Waterloo Biofilter Systems Inc.
on-site wastewater treatment

RE-USE OF TREATED SEWAGE USING BIOFILTER TECHNOLOGY

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INTRODUCTION

Re-use of highly treated sewage is a positive step in managing water supplies, and can be defined as “indirect” (i.e., after passage through the groundwater table or through a treatment plant), or “immediate” (i.e., used right away in the house for toilets, laundry, irrigation, etc.). Immediate re-use is usually met with reluctance, even though people may acknowledge that their potable water was once sewage wastewater some time in the past. People may also swim in river water much dirtier than highly treated sewage without problem: the sense of immediacy is not there. However, once the treatment system is seen to be robust, and the water quality consistent, our experience is that this initial reluctance is overcome, and immediate re-use is accepted by golf course staff and homeowner alike.

This paper describes several sites in Canada and Korea where sewage is treated by the WATERLOO BIOFILTER absorbent trickle filter technology (Jowett et al., 2000). The WATERLOO BIOFILTER foam medium forms an interconnecting, three-dimensional reticulate solid framework with high surface area, high porosity, high absorption, and dual pathways for air and wastewater (Jowett, 1997b; Jowett, 1999) and is detailed in Jowett and McMaster, 1995 and Crites and Tchobanoglous, 1998.

WATER RE-USE PARAMETERS

The following criteria and guidelines for water re-use are taken from Jowett, 1997a. For swimming and bathing, the water should be aesthetically pleasing, and without objectional colour, odour, taste, or turbidity. Because of eye irritation, the pH should be within the range of 6.5 to 8.5. The use of the water should also not cause diseases or infection of the intestinal tract, the eye, ear, nose or throat, or in the skin, such as what might be caused by pathogenic bacteria, fungi, protozoa, worms, or viruses. Pathogen indicators such as fecal coliform and total coliform limits for bathing are 100 and 1000 CFU/100 mL, respectively.

The EPA Guidelines for Water Reuse 1992 summarizes criteria for reclaimed water treatment, in general to the highest degree. For BOD and TSS, the preferred averages are <5 mg/L so that disinfection is effective, but always <30 mg/L. For coliform bacteria limits, generally non-detectable to 200 CFU/100 mL is required for reclaimed water. Maximum turbidity values of 2-5 NTU are recommended.

NORTH BAY RESIDENCE: SWIMMING WATER QUALITY WITH NO ACTIVE DISINFECTION

A demonstration site installed by the City of North Bay uses a WATERLOO BIOFILTER to treat septic tank effluent followed by a small up-flow filter to remove phosphorus (Hutchinson and Jowett, 1997) (Fig. 1). This site is not designed for re-use, but the effluent is consistently clean enough to be meet all EPA criteria, without further disinfection, for swimming or toilet flushing. Table 1 shows the system performance with an initial 6 months using red sandy soil in the up-flow filter, and the last 12 months using expanded clay aggregate.

Table 1. North Bay domestic sewage analyses after Waterloo Biofilter and up-flow filter treatment 1998-1999; n = number of samples; OUT = arithmetic mean

Parameter	Jan 98 to Jun 98 soil up-flow			Jul 98 to Aug 99 expanded clay up-flow		
	n	OUT mg/L	% removal	n	OUT mg/L	% removal
BOD_5	6	<5	~95	7	~5	~95
TSS	6	<2	>94	7	<5	>94
TN	6	19	~50	7	20	~50
E.coli CFU/100mL	4	660	>99	18	<29	99.98

An astonishing aspect of this trial, and one important to wastewater re-use, is the excellent removal of coliforms in the up-flow filter. After 6 months, the effluent had <75 CFU/100mL and dropped to <16 in the last six months (Fig. 2), approaching what UV disinfection can achieve. These and other results increase confidence for lower level re-uses such as toilet flushing or garden use, without the need for high-maintenance disinfection.

BUZZARDS BAY FACILITY: CONSISTENCY OF TRIPLICATE TESTS

The Buzzards Bay facility on Cape Cod tests septic tank treatment systems in triplicate over a 2-year period, winter and summer, using non-comminuted sewage and using household diurnal flows (Millham et al., 2000). This compares well with NSF Standard 40 test of only 6 months duration using comminuted sewage without winter testing required.

Three WATERLOO BIOFILTERS have been tested since June 1999 and the results given in Table 2. The design is similar to Fig. 1 without the up-flow filter. Millham et al. (2000) report arithmetic average values of total BOD_5 = 9.5 and TSS = 6.2 mg/L to June 2000, for removals of 95% and 96% respectively, comparing favourably with the median results in Table 2 which are more representative of a non-normal distribution.

Table 2. Buzzards Bay sewage analyses after Waterloo Biofilter treatment June 1999 to March 2000; n = number of samples; OUT = median 50 percentile

Parameter	Waterloo Biofilter Effluent		
	n	OUT mg/L	% removal
c+nBOD_5	42	9	94
TSS	37	3	98
NH_3-N	41	0.8	97
TN	42	14	58
Fecal Coliform (CFU/100 mL)	42	31,000	99

CLUBLINK GOLF COURSES: IRRIGATION RE-USE OR SURFACE DISCHARGE

The sewage treatment system at CLUBLINK'S Rattlesnake golf club is designed to handle the large fluctuations in flow rates typical of a major golf course hosting social functions and tournaments. CLUBLINK'S criteria were to treat the effluent to a very high degree so that their wastewater would become a useful resource for golf course irrigation. Average flows of 60 m^3/d with 5-day peaks of 120 m^3/d at 250 mg/L cBOD were the design loadings. Due to commercial success of the golf course and water conservation measures, higher organic loadings of 400-1200 mg/L cBOD and 200-500 mg/L TSS are typical, but the treatment system is handling the high organic and nitrogen loading.

The treatment system (Fig. 3) includes: (1) a raw sewage pumping station, (2) 3-day capacity septic tanks with fine-screen effluent filters, (3) 1-day capacity recirculation and pump tank to dose the BIOFILTER, (4) WATERLOO BIOFILTERS in 6 poured-in-place concrete tanks, (5) 120 m^3/d recirculation design for BOD and ammonium removal and for mitigation of hydraulic surges, (6) alum addition to the septic tanks for phosphorus and solids removal, and (7) ultraviolet disinfection for the final BIOFILTER effluent. Other important aspects of the design are (8) a custom electronic remote monitoring system, and (9) professional operations management secured by CLUBLINK. The system started up in mid-May 1999, and within one month, was within compliance (Table 3). The water is diverted to irrigation ponds, now a useful resource. Staff members nervous about re-using wastewater in their irrigation lines were shown the facility, and after seeing the clarity of the effluent, they were comfortable with using it.

Blue Springs golf club has a similar process design with flow rates of 30 m^3/d. Here, the BIOFILTERS are contained in above-ground polyethylene tanks, a more flexible configuration where BIOFILTERS are added as needed. Table 3 shows the excellent treatment of high initial cBOD (60-1290 mg/L) and TSS (70-2900 mg/L). Results are similar to Rattlesnake except for lower TN in the effluent (10 compared to 22 mg/L), likely due to controlled air flow. The removal of total nitrogen from 53 to 22 mg/L (58% removal) at Rattlesnake and 80 to 10 mg/L (88%) at Blue Springs is a significant reduction, and continues through the low-flow, winter months. Both sites operate well through the winters when only 2-5 m^3/d of flow are sustained, with no extra additives or foodstuffs required.

Table 3. Waterloo Biofilter effluent at two ClubLink golf courses, August 1999 to January 2001, n = number of samples; OUT = median 50 percentile

Parameter	Rattlesnake Golf Club			Blue Springs Golf Club		
	n	OUT mg/L	% removal	n	OUT mg/L	% removal
$cBOD_5$	72	2.3	>99	75	3.0	>99
TSS	72	3.0	99	75	3.0	98
NH_3-N	72	0.3	99	75	0.5	99
TN	20	22	58	23	10	88
TP	72	1.0	84	75	0.7	89
E. coli CFU/100mL	67	1	~100	70	1	~100

KOREAN RESTAURANT SYSTEMS: SURFACE DISCHARGE TO POTABLE WATER SUPPLY

The tourist area of Yangpyung in Korea contains the headwaters of the Han River, a major source of drinking water for the City of Seoul. As an official demonstration, WATERLOO BIOFILTERS were installed at 30 restaurants by Batu Enviro-Tek with direct discharge to the river (Fig. 4). Because of the very strong wastewater, even the recirculation tanks average 240 mg/L BOD, but the effluent is <10 mg/L (Table 4), and of course there is a direct correlation between effluent quality and organic mass loading rate on the Biofilter.

Table 4. Waterloo Biofilter effluent from 24 restaurants, Yangpyung, Korea, March 2000 to June 2000. Median 50 percentile of 24 sites each month

Parameter mg/L	March	April	May1	May2	June	Overall
BOD_5	2.2	4.8	6.2	5.0	4.2	5.2 (1-21)
TSS	4.5	3.0	3.0	4.5	3.3	5.3 (1-17)

The effluent is fed to the Han River without disinfection to be re-used downstream for local potable water. Consistency like this provides confidence to the regulator and as a result, the WATERLOO BIOFILTER has been chosen to install 20 systems for the Korean Army on flows of 50 to 1000 m^3/d, with additional contracts with Yangpyung Province.

"HEALTHY HOUSE" SYSTEM: IMMEDIATE HIGH-LEVEL RE-USE

Even more confidence is required by the regulator to allow for immediate re-use of treated wastewater in a house, for low-level uses such as toilets, but especially for high-level uses such as laundry, baths and showers. Other papers on the CMHC's Toronto "Healthy Houses" have been written (Townshend et al., 1997), and this design is now well known because the treated wastewater has been re-used immediately in the houses for toilets, laundry, and baths and showers since 1996. The technology has been transferred to the Canadian Arctic where water supply is difficult and expensive. The septic tank is a flexible bladder tank and the BIOFILTER occupies 3.3 m^3 in the basement. Back-washed sand filtration, ozonation, and remote monitoring are part of the security, and the effluent is re-used in toilets.

"ECO-NOMAD" CONTAINERS: IMMEDIATE LOW-LEVEL RE-USE

A novel innovation in housing is the EcoNomad system with all mechanical and electrical utilities in a shipping container. The container is enclosed by the housing structure with only simple plumbing and electrical connections made on site. This CMHC project uses the WATERLOO BIOFILTER effluent directly for toilet flushing only. It is in use at one site in Northern Ontario for re-use in toilets, with 13 sites planned for 2001.

CONCLUSIONS

The Waterloo absorbent trickle filter is treating residential, restaurant, and commercial golf clubhouse wastewater effectively, and the effluent is reclaimed as a resource rather than a waste product. Simple treatment steps such as septic tanks, recirculation, and up-flow filters ensure consistency of aesthetic quality to overcome suspicion by the end user. Depending on level of end use, components can be added for additional treatment.

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