A Reclaimed Water for Beneficial Reuse (RWBR) Pilot Program for a Community in New Jersey, USA

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ABSTRACT: As New Jersey's population expands and water needs increase, the concept of using reclaimed water for beneficial reuse (RWBR) is attracting more attention as a method to relieve potable water demands. A RWBR pilot program was conducted at the Hawk Pointe wastewater treatment plant (HPWTP) located in Washington Township, Warren County, New Jersey, USA. The reclaimed water is proposed for irrigation of the community golf course. A monitoring program for total suspended solids (TSS) and turbidity was conducted. The results show that the HPWTP consistently produces a low TSS and low turbidity effluent that is well below New Jersey's requirements for RWBR. Furthermore, a TSS and turbidity correlation study was conducted using the mixed liquor suspended solids from the HPWTP's first aeration tank. The results show a well-defined linear correlation between TSS and turbidity.

Keywords: Water reclamation, water resource management, water reuse, turbidity, total suspended solids, New Jersey.

Introduction

Reclaimed wastewater is now considered to be a valuable resource which can be used for a variety of purposes such as landscape irrigation, agricultural irrigation, toilet and urinal flushing, industrial applications, fire protection, aesthetic fountains and lagoons, construction applications, environmental and recreational applications, groundwater recharge, and vehicle washing (U.S. EPA, 2004). Some of the benefits of using reclaimed wastewater include a reduction in valuable potable water demand, a reduction of pollutant loading to surface waters, a reduction on the diversion of freshwater from sensitive ecosystems, and postponement or elimination of costly development of new water sources and treatment facilities.

Reclaimed wastewater is an integral part of the water supply infrastructure in numerous states throughout the United States. The state of New Jersey is beginning to discover the benefits and importance of reclaimed water for beneficial reuse (RWBR). New Jersey is the most densely populated state in the nation, and its population is projected to grow considerably in the near future (U.S. Census Bureau, www.census.gov). Consequently, an increasing strain is being applied to the existing water supply, and safe alternatives are sought to alleviate potable water demands.

One of the most important objectives in a RWBR program is to assure that public health protection is not compromised. Appropriate monitoring programs are necessary to make sure that sufficient water quality is maintained and regulations are not violated. Monitoring requirements vary from state to state and are dependant on the type of reuse application (U.S. EPA, 2004). The New Jersey Department of Environmental Protection (NJDEP) monitoring requirements for a Category 1 RWBR permit, as applied to The Village at Hawk Pointe community, are listed in Table 1. A NJDEP Category 1 RWBR permit is for public access systems where the highest degree of treatment is required (NJDEP, 2005). The NJDEP notes that the total suspended solids (TSS) should not exceed 5 mg/L before disinfection and a statistically significant correlation between turbidity and TSS shall be established prior to a reuse system being placed into operation. This correlation should be done as part of a daily monitoring program for at least thirty days.

In November 2004, the property owner of The Village at Hawk Pointe community, or Asbury Farms, received a Category 1 RWBR permit modification from NJDEP to use the treated effluent from the Hawk Pointe wastewater treatment plant (HPWTP) to spray irrigate the community golf course. The Village at Hawk Pointe community is located in Washington

Township, Warren County, New Jersey, USA, and is currently under development. In addition to the existing golf course and the on-site wastewater treatment plant, the community, once fully developed, will consists of 120 age-restricted housing units (as of this study 80 units have been constructed), 100 assisted living units, 340,000 square-feet of commercial space, and a hotel/restaurant. An aerial photograph of The Village at Hawk Pointe community is shown in Figure 1.

Wastewater is conveyed to the HPWTP by a collection system, consisting of a combination of gravity sewers and pump stations. From the collection system, wastewater first flows into a trash trap for the removal of non-biodegradable solids. The wastewater then flows by gravity to a flow equalization tank. Transfer pumps then convey wastewater to the biological treatment system, which consists of an anoxic tank followed by two consecutive aeration tanks. Within the anoxic tank, wastewater provides a carbon source for denitrifying bacteria that reduce nitrate and nitrite in a nitrified mixed liquor. Wastewater then flows by gravity from the anoxic reactor into the aeration tanks and undergoes carbonaceous oxidation and nitrification. Air is supplied to the aeration tanks by one of two positive displacement blowers, and alkalinity control is provided through the automatic injection of sodium hydroxide. It should be noted that the aeration system generally requires minimal alkalinity adjustment due to the alkalinity produced by the denitrification process in the anoxic tank. The wastewater is then pumped through an ultra-filtration membrane (Zeeweed® 500 reinforced membranes, Zenon Environmental Inc., Oakville, Ontario, Canada) for liquid/solid separation. This innovative ultra-filtration membrane system is capable of removing suspended solids down to very low levels. A recycle system is used to return solids removed by the membranes back to the anoxic tank to enhance the denitrification process. The return sludge flow rate is determined by maintaining a target mixed liquor suspended solids (MLSS) concentration in the aeration tanks between 8,000 and 12,000 mg/L. MLSS is the mixture of solids resulting from combining recycled sludge with influent wastewater in the bioreactor (Burton and Stensel, 2003). Sludge is periodically transferred to the sludge holding tank and hauled off-site. Finally, the clear effluent from the ultra-filtration membrane is pumped to a ultra-violet (UV) disinfection unit and flows by gravity out of the treatment plant to the effluent dosing tank. The design capacity of the HPWTP is 82,000 gallons per day (GPD), and is currently operating at a range between 15,000 and 20,000 GPD. The HPWTP is permitted to discharge 82,000 GPD of treated effluent to groundwater through three infiltration/percolation ponds (see Figure 1).

TSS and Turbidity Monitoring Program

The HPWTP TSS and turbidity monitoring program started on June 18, 2004, and ended on September 1, 2004. During this time, thirty sampling sessions were conducted on various days. For each sampling session, the turbidity (in nephelometric turbidity unit, or NTU) is recorded from a low range process turbidimeter (Hach model 1720E, Loveland, Colorado, USA), which was installed inline just before the UV disinfection unit. The turbidimeter continuously monitors turbidity of all flow passing through the HPWTP. After recording the turbidity value, the discharge from the turbidimeter was collected using a 500 mL container. The discharged sample was sealed and sent to a NJDEP certified laboratory for TSS analysis.

Figure 2 shows the recorded turbidity results as a function of sampling date. Note that the starting date (day 1) was June 18, 2004, and the last measurement was recorded on September 1, 2004 (day 76). The average turbidity of the thirty measurements was 0.09 NTU. The laboratory reported a non-detect TSS concentration for all samples except sample number 2 (day 4), which was at the laboratory detection limit of 2 mg/L. However, it was assumed that this value was an experimental error and the result was therefore neglected. The monitoring program results show that the HPWTP consistently produces a low turbidity and low TSS effluent that is well below the NJDEP monitoring requirements (see Table 1).

TSS and Turbidity Correlation Study

The correlation between TSS and turbidity is site specific and depends on the size and type of particles in the wastewater stream. As noted earlier, turbidity is continuously monitored at the HPWTP. If a correlation can be developed between TSS and turbidity, turbidity measurements can be used as a surrogate for instantaneous TSS concentration estimation (Bertrand-Krajewski, 2004). However, laboratory data from the monitoring program showed that the effluent samples had TSS concentrations less than the detection limits of the analytical instruments used by the reporting laboratory. Consequently, a correlation between turbidity and TSS could not be obtained from the monitoring program.

The TSS and turbidity correlation study was conducted on July 27, 2004. The correlation study was conducted using a MLSS sample, which was taken from the first aeration tank. At the time of the study the MLSS level was 8,800 mg/L. Five different volumes of this MLSS sample were separately diluted with approximately 40 gallons of the treated effluent in a 55-gallon drum. For each MLSS dilution, the 55-gallon drum was continuously mixed with a mixing rod while a submersible pump was used to transfer the diluted MLSS to the turbidimeter for turbidity measurement. Two samples from each MLSS dilution were sealed and sent to a NJDEP certified laboratory for TSS analysis (10 total samples).

Figure 3a shows the TSS and turbidity measurements for each of the five MLSS dilution batches. The plotted TSS concentration for each batch of diluted MLSS represents the average concentration from two laboratory measurements. Figure 3b shows the plot of TSS (mg/L) and corresponding turbidity (NTU) obtained from the correlation study. The solid line represents a linear regression line between TSS and turbidity, and it was determined as

$$\text{TSS (mg/L)} = 1.54 \times \text{Turbidity (NTU)} \tag{1}$$

From the linear regression line of equation (1), a coefficient of determination of $R^2 = 0.9996$ is obtained. This value indicates that TSS and turbidity values are highly correlated. Note that for wastewater treatment plants using UV disinfection, the NJDEP turbidity requirement is 2 NTU. The corresponding calculated TSS concentration from equation (1) is 3.08 mg/L, which is below the NJDEP TSS requirement of 5 mg/L (Table 1). Therefore, as long as the turbidity measurement is below 2 NTU, the TSS requirement of 5 mg/L is not violated.

Conclusions

This paper presents the results of a reclaimed water for beneficial reuse (RWBR) pilot program conducted at the Hawk Pointe wastewater treatment plant (HPWTP) located in Washington Township, Warren County, New Jersey, USA. The HPWTP is part of a developing community and the reclaimed water is proposed for irrigation of the community golf course. The HPWTP uses a traditional biological treatment system in conjunction with an innovative ultra-filtration membrane system to remove turbidity and suspended solids. A monitoring program for total suspended solids (TSS) and turbidity was conducted and the results show that the HPWTP consistently produces a low TSS and low turbidity effluent that is well below New Jersey's requirements for RWBR. Furthermore, a TSS and turbidity correlation study was conducted by diluting a mixed liquor suspended solids sample from the HPWTP's first aeration tank. The results show a well-defined linear correlation between TSS and turbidity.

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References

Bertrand-Krajewski, J. L. (2004) TSS concentration in sewers estimated from turbidity measurements by means of linear regression accounting for uncertainties in both variables. *Water Science and Technology,* **50** (11), pp 81-88.

Burton, F.; Stensel, H. (2003) Wastewater Engineering, Treatment and Reuse, 4th edition. McGraw Hill, New York, USA.

U.S. EPA (2004) Guidelines for Water Reuse. U.S. Environmental Protection Agency. EPA/625/R-04/108.

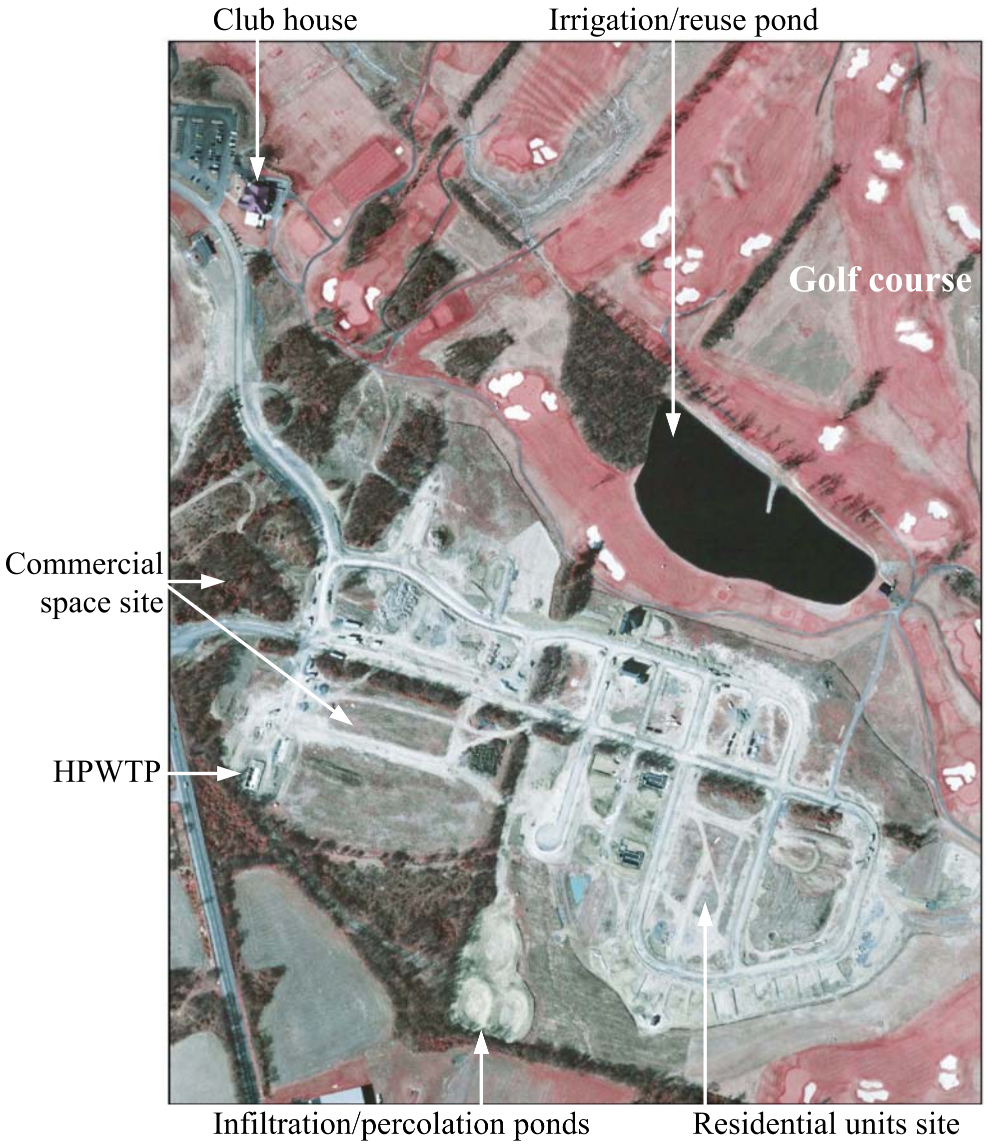
NJDEP (2005) Technical Manual: Reclaimed Water For Beneficial Reuse. New Jersey Department of Environmental Protection, Trenton New Jersey, USA.

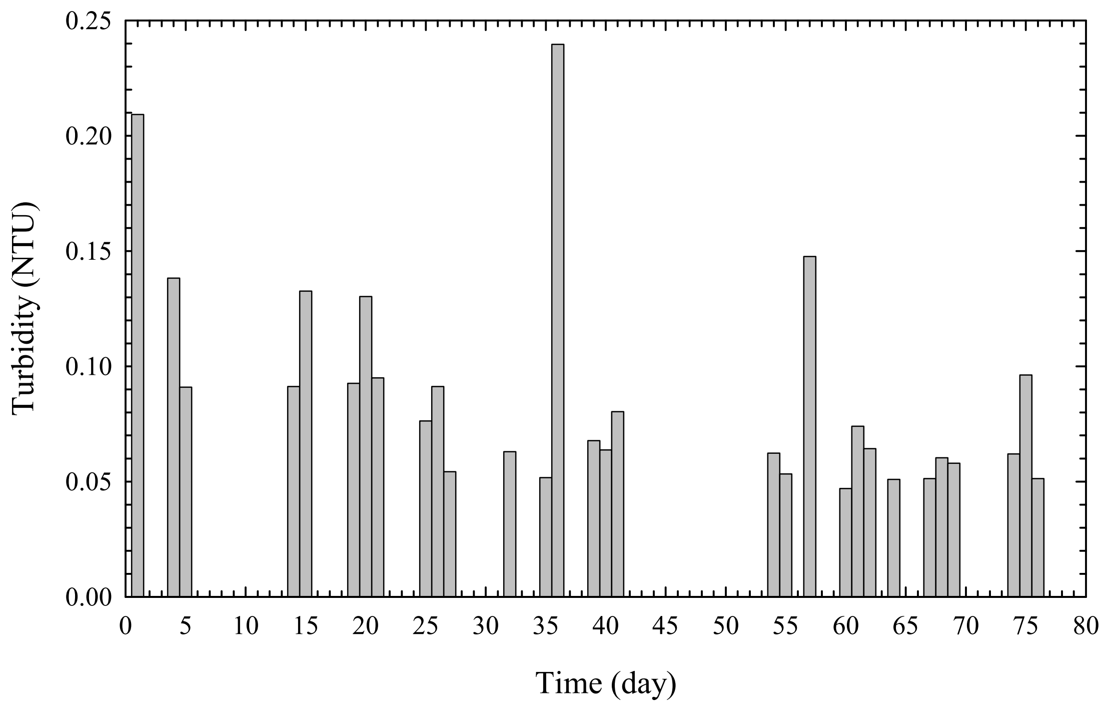
Figure Captions

Figure 1. Aerial photograph of The Village at Hawk Pointe community.

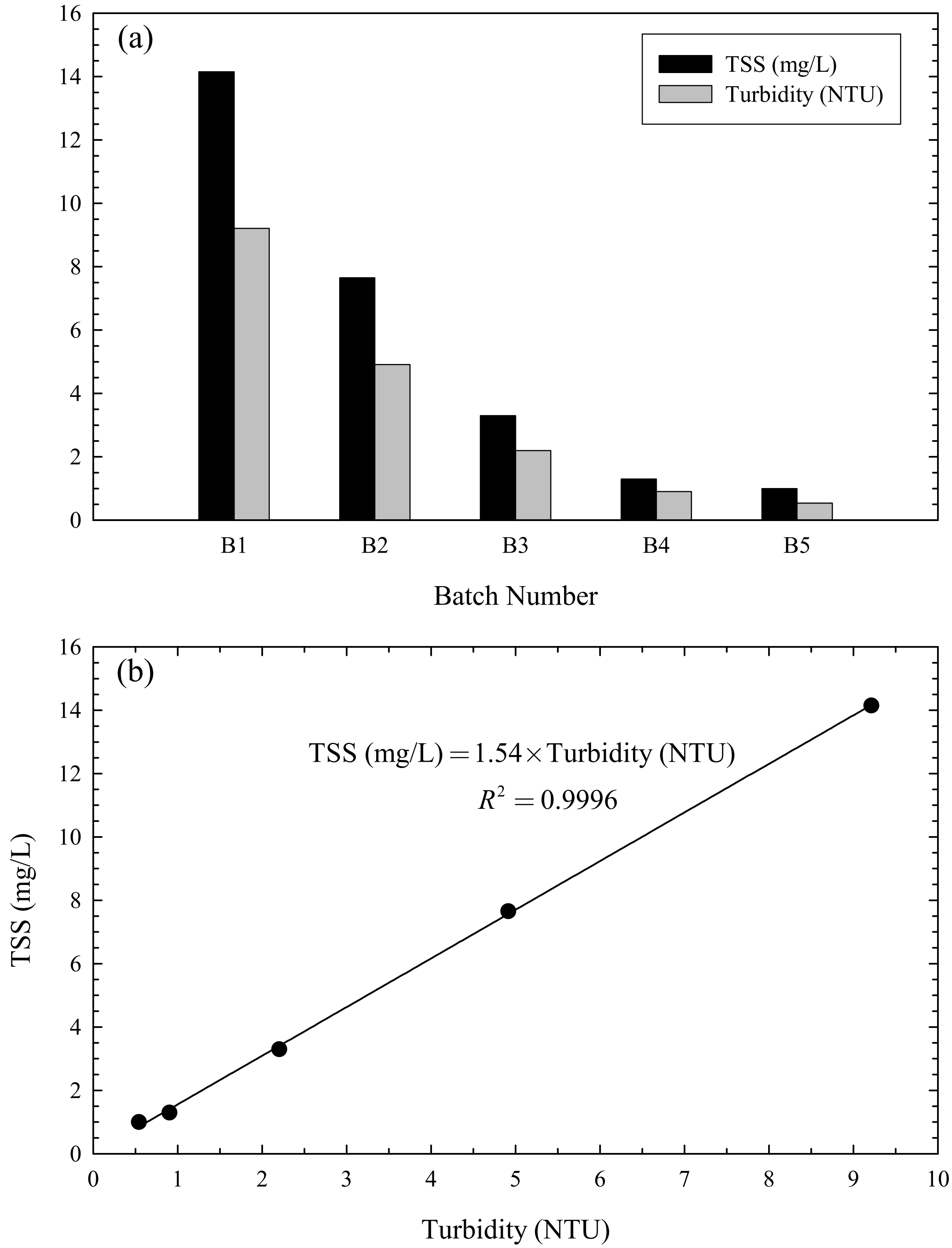
Figure 2. Turbidity monitoring program results at the Hawk Pointe wastewater treatment plant.

Figure 3. (a) TSS concentrations and corresponding turbidity values for the five MLSS dilution batches, and (b) Plot of TSS concentrations and corresponding turbidity values (circles).


Club house
Irrigation/reuse pond
Golf course
Commercial
space site
HPWTP
Infiltration/percolation ponds
Residential units site


Turbidity (NTU)
0.25
0.20
0.15
0.10
0.05
0.00
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Time (day)

F2



(a)
TSS (mg/L)
Turbidity (NTU)
B1
B2
B3
B4
B5
Batch Number
(b)
TSS (mg/L) = 1.54 × Turbidity (NTU)
R^2 = 0.9996
TSS (mg/L)
Turbidity (NTU)

F3

Table 1. Hawk Pointe Category 1 RWBR Monitoring Requirements (NJDEP, 2005)

Parameter	RWBR Requirement	Sample Type
Flow Rate		Continuous
Total Nitrogen	10 mg/L	Grab
TSS	5 mg/L	Grab
Fecal Coliform	14 coliforms per 100 mL (2.2 weekly average)	Grab
Turbidity	2 NTU	Continuous
Disinfection	100 mJ/cm^2 (UV)	Continuous