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Project Summary

Performance Characteristics of Package Water Treatment Plants

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The quality of water produced by package water treatment plants was investigated in a study conducted on-site at six selected facilities. These sites are but a small sample of the more than 500 package installations identified by manufacturers and state agencies through a questionnaire. The list by no means includes all package plants operating in the United States.

The six selected plants were in year-round operation, used surface water sources, and served small populations. The plants were monitored to assess their performance and ability to supply water meeting the Interim Primary Drinking Water Regulations.

At each plant, grab samples of the raw water, the treated water, and water from the distribution system were collected intermittently over a 2-year period. Data on turbidity, total coliforms, and chlorine residuals were recorded on all visits. Standard plate counts, chemicals listed in the U.S. Environmental Protection Agency Drinking Water Regulations, and trihalomethanes were determined intermittently.

Only one treated water sample (a distribution sample) showed any coliforms. Sixty-eight percent of the standard plate counts for treated water showed densities of 10 or fewer organisms per milliliter.

Three of the plants met the 1-ntu turbidity standard on nearly all occasions, whereas the other three plants met it on fewer than half of the sampling trips. Failure of the latter plants to perform well is attributed to the variability and quality of their raw water sources and/or to the lack of skilled operators with sufficient time to devote to treatment.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The problem of providing acceptable water supplies to the public is particularly acute for small communities with limited financial resources and a lack of competent treatment plant operators. Isolated recreational areas also must provide acceptable drinking water to their visitors and staff, often without skilled or experienced water treatment personnel.

During the last 20 years, cost savings have been achieved in such situations by using package water treatment plants. A package plant generally consists of prefabricated and largely preassembled clarification and filtration units (Figure 1). These plants are reputed to require minimal operational skill and to be a viable and economical low-flow alternative to the custom-built facility. Six such plants were selected for study (Tables 1 and 2). These plants were monitored to assess their performance and ability to supply water meeting the National Interim Primary Drinking Water Regulations, particularly the turbidity and microbiological requirements.

The design of a custom-built treatment plant should depend on an evaluation of the nature and quality of the particular water to be treated. Package plants are designed with the goal of producing a satisfactory quality of treated water from a range of influent waters. Flow rates for

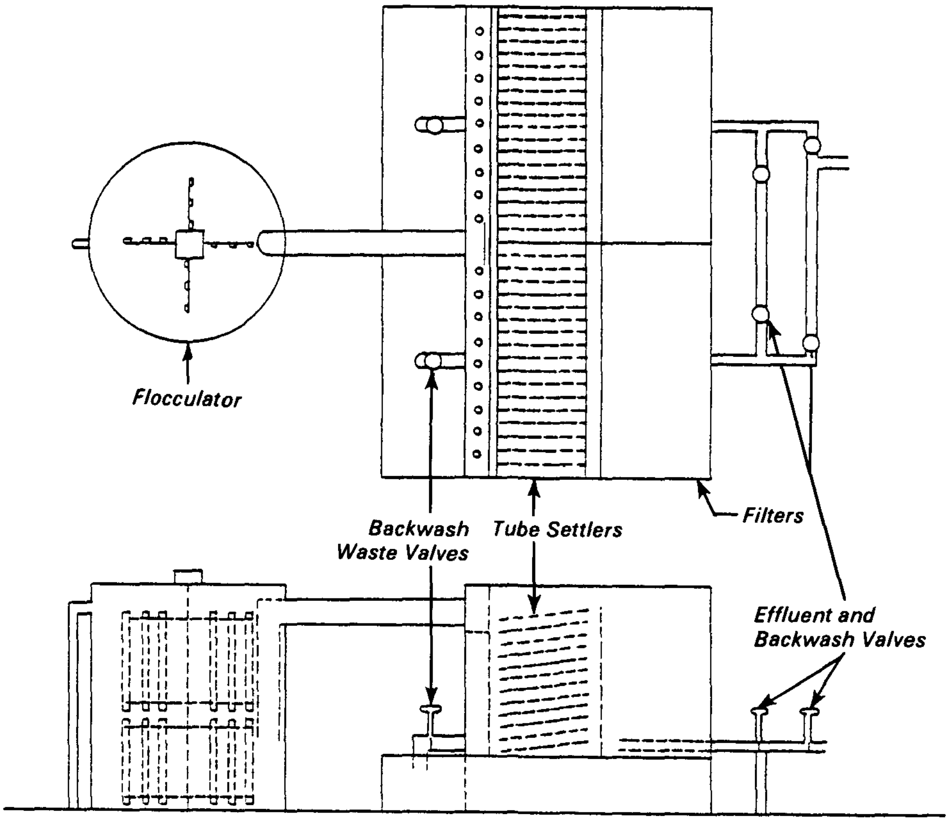

Figure 1. *Neptune Microfloc AQ-40 Water Treatment Plant (200 gpm capacity).*

plants on the market range from 10 to 2100 gpm.

The financial and personnel limitations faced by small communities and recreational areas can be alleviated by prefabricated plants of this type. The question of the adequacy of treatment provided by these plants as they are managed and operated by small communities and recreational areas is not answered by data available in the literature. This study was undertaken to collect reliable onsite information on the quality of treated water produced by package water treatment plants.

Results

Turbidity

The six water treatment facilities selected for field research had varied success in their turbidity removals. Four of the plants (C, T, W, and P) had uniform, high-quality source waters, but only three of these (C, T, and W) consistently met the 1-ntu effluent turbidity standard. The other three plants (P, V, and R) met the standard on fewer than half of the visits made to them (Table 3).

The performance difficulties of Plants P, V, and R involved the short detention times inherent in the design of the treat-

Table 1. *Facilities Studied*

Site	*Model Year*	*Design Flow Rate (gpm)*	*Population Served/ No. of Meters*	*Average Volume Per Day (gal)*	*Group Served*	*Type of Distribution Pipe Used*	*Source*
W	*Neptune Microfloc AQ-40 1973*	*200*	*1500/552*	*110,000*	*City*	*PVC*	*Surface impoundment*
T	*Neptune Microfloc AQ-40 1973*	*200*	*1000/360*	*78,000*	*City*	*PVC, cast iron asbestos cement*	*Surface impoundment*
V	*Neptune Microfloc AQ-40 1976*	*200*	*----/423*	*72,000*	*PSD**	*PVC*	*River*
M	*Neptune Microfloc AQ-112 1972*	*560*	*----/1680*	*330,000*	*PSD**	*PVC*	*River*
P	*Neptune Microfloc Water Boy 1972*	*100*	*----/411*	*82,000*	*PSD**	*PVC*	*Surface impoundment*
C	*Permutit Permujet 1971*	*200*	*State park*	*57,000*	*State park*	*Asbestos cement*	*River*

**PSD - Public Service District*

Table 2. *Treatment Process Characteristics*

Site	Pre-Chemical Addition	Rapid Mix Type	Rapid Mix d.t (sec.)	Flocculation Type	Flocculation d.t (min.)	Sedimentation Type	Sedimentation Loading (gpd/ft²)	Filtration Media		Filtration Rate (gpm/ft²)	Notes
W	Cl, alum. soda ash	In pipe	3	Paddle	12.8	Tubes	100	Mixed anthracite silica sand garnet sand	 18 in 9 in 3 in	5	Poly added before tubes
T	Cl, alum. soda ash, poly	In pipe	3	Paddle	12.8	Tubes	100	Mixed same as above		5	Post soda ash
V	Cl, alum. soda ash, poly	In pipe	3	Paddle	14	Tubes	100	Mixed same as above		5	Post sodium hexameta-phosphate
M	Cl, alum. soda ash, poly	Chamber	30	Paddle	10	Tubes	100	Mixed same as above		5	
P	Cl, alum. soda ash, carbon (summer)	Chamber not used	--	Paddle	10	Tubes	150	Mixed same as above		5	
C	Cl, alum. soda ash, poly	In pipe	--	Upflow solids contact 2 hr. d.t. rise rate - 1 gpm/ft²				Silica sand	24 in	2	Soda ash added before filtration

Table 3. *Plant Turbidity Values (ntu)*

Plant C Raw	Plant C Clearwell Effluent	Plant W Raw	Plant W Clearwell Effluent	Plant T Raw	Plant T Clearwell Effluent	Plant V Raw	Plant V Clearwell Effluent	Plant R Raw	Plant R Clearwell Effluent	Plant P Raw	Plant P Clearwell Effluent
8.5	0.3	--	0.9	10.0	1.9	4.0	1.8	-	0.2	12.0	0.8
6.2	0.2	5.0	0.3	8.0	0.2	12.0	2.8	39.0	3.8	4.4	2.4
1.2	0.3	4.2	0.4	6.0	0.4	* --	9.6	40.0	2.6	-	7.0
1.6	0.1	19.0	0.8	3.2	1.1	35.0	1.5	27.0	2.4	3.5	1.5
2.2	0.1	9.2	2.0	3.2	0.2	*42.0	2.0	6.0	1.2	2.0	0.1
4.0	0.1	11.5	0.3	3.2	0.2	*10.0	2.4	3.8	0.1	1.2	0.5
12.6	0.7	12.0	0.2	5.8	0.2	*90.0	8.5	73.0	11.0	15.6	9.7
5.2	0.2	11.0	0.3	10.4	3.2	*28.0	5.4	* 3.6	0.1	3.1	2.2
2.2	0.2	29.7	0.9	3.4	0.7	*19.0	0.3	3.8	0.3	17.2	1.9
		12.8	0.2			*47.0	1.2	6.0	0.5		
						*13.0	0.8	*70.0	16.0		
						* 8.0	0.3	*25.0	3.4		
						* 6.0	0.3	*>100.0	55.0		
						*>100.0	0.5	*>100.0	31.0		
						*60.0	0.5	* 8.5	2.2		
						24.0	1.2	4.3	0.4		
						13.0	0.3	* 4.0	1.0		
						2.7	1.2	* 9.6	1.9		
						1.2	1.0	19.1	1.1		
						3.3	0.5	64.0	6.9		
								8.2	1.0		

*Averaged Values for Day

ment units, the lack of skilled operators with sufficient time to devote to treatment, and (in the cases of V and R) the variability and quality of the source water.

The stream source quality at Plant V was quite variable with the turbidity often exceeding 100 ntu. The first eight daily values obtained at this site over a 4-month period did not comply with the 1-ntu standard. But data indicated much improvement after operational methods were upgraded and needed maintenance was performed. Daily average turbidities for the last 12 sampling days over an 8-month period met the turbidity MCL, although some values exceeded the limit. Before the changes in maintenance and operation, this plant did not consistently reduce influent turbidities of 35 to 50 ntu to adequate levels. But afterwards, effluent turbidities were less than 1 ntu even when influent turbidities increased from 17 to 100 ntu within a 2-hour period.

Plant R difficulties in turbidity removal were also caused by highly variable source water turbidities and inadequate staff time. This site had influent turbidity levels that ranged from 3.5 to > 500 ntu. According to product literature and a manufacturer's representative, these peaks could not be adequately treated at the design capacity of the unit. In fact, both Plants V and R caused State health department engineers to voice reluctance about approving plans for future installations of similarly designed units with such highly variable stream sources. Nonetheless, even with influent turbidities of less than 30 ntu, the plant did not produce an effluent below 1 ntu because of inadequate operator skill.

Though Plant P had a reservoir as its source and thus showed consistently low influent turbidities (17.2 ntu maximum), effluents exceeded the 1 ntu limit in six out of the nine samples taken. This poor record was traceable to lack of operator attention. Though the plant operated an average of nearly 14 hours per day, the operator was present for no more than 2 hours.

Plants C, W, and T met the turbidity requirements on nearly all occasions: Plant C effluents measured 1 ntu at every sampling, Plant W exceeded the limit once, and Plant T failed to meet the MCL twice. At Plant T, two high effluent turbidities of 1.9 and 3.2 ntu were measured and found to be caused by a pump failure and a distribution system problem requiring extensive operator attention. All three facilities had low-turbidity sources (1.2 to 29.7 ntu) and high-quality operators.

Total Coliforms and Standard Plant Counts

Total coliform determinations for treated water from all six plants showed no coliforms, with the exception of one distribution system sample taken at a residence. Total coliforms in raw water samples from the six water treatment plants varied up to 10,000/100 mL. Two of the three facilities using river sources had the highest total coliform densities, with typical raw water levels between 1,000 and 10,000/100 mL. The plants using impoundments for their sources had raw water total coliform densities approximately one order of magnitude lower than this range.

The standard plate counts for treated water from all six facilities were low: 30 percent of the samples had counts that were lower than 1/mL, and 68 percent showed densities of 10/mL or lower. The highest standard plate count was 2700/mL.

The low standard plate counts and the absence of coliforms in the treated water examined indicate that all six water treatment facilities produced adequately disinfected water.

Inorganic Contaminant

The chemical analyses performed by the U.S. Environmental Protection Agency (EPA) for inorganic contaminants listed in its drinking water regulations show that no maximum contaminants levels (MCL) listed in the primary regulations were exceeded in any influent and effluent samples. Five effluent samples had manganese concentrations greater than the secondary MCL's, and two treated water samples exceeded the recommended secondary MCL for iron. Results of the effluent and distribution system analyses revealed that 15 of 18 treated water samples exceeded sodium levels of 20 mg/L.

Note that the operators of these facilities were not trying to control sodium, manganese, or iron at the time these samples were collected. Their major concerns were turbidity removal and adequate disinfection.

Trihalomethanes

Four of the six plants studied had at least one treated water instantaneous trihalomethane (THM) sample with a total THM concentration greater than 0.10 mg/L. The small size of these water systems precludes them from having to comply with any present THM regulations. The point of chlorination and often the large free chlorine residuals (>2. mg/L) detected in the treated water contribute to these high THM levels. All six of the plants were originally equipped with pre- and post-chlorination capabilities, but all of the plants practiced prechlorination during the study.

General Observations

The three facilities that were most successful (sites C, T, and W) had competent operational staffs who devoted sufficient time to water treatment. All had knowledge of water treatment or great familiarity with their plants and dedication to their work. These plants were characterized by frequent monitoring of the influent and effluent quality. Improvement of the water quality at site V came from increased maintenance and more frequent sampling of water through the plant. The staff at site R lacked adequate knowledge and time to devote to water treatment. Distribution system maintenance requirements kept this staff from properly maintaining and monitoring their plant. The small percentage of time spent by the operators at site P resulted in poor effluent quality, even though the influent turbidity was quite low.

Conclusions

Package water treatment plants manned by competent operators can readily treat the turbidity and bacteria of surface waters that have fairly consistent quality. Reservoirs have proved satisfactory for providing acceptable influent waters.

Package plants using variable sources (e.g., streams) require a high degree of operational skill and near constant vigilance by the operators. But regardless of their source quality, all package plants require a minimum level of maintenance and operational skill. Lack of this minimum skill and attention precludes consistently successful turbidity removal, regardless of the influent quality.

Most package plants are located in rural or remote areas where it may be difficult to hire well trained operators. Small communities may have to greatly increase salaries to attract well qualified operators.

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***Thomas J. Sorg** is the EPA Project Officer (see below).*

The complete report, entitled "Performance Characteristics of Package Water Treatment Plants," (Order No. PB 83-161 018; Cost: $11.50, subject to change) will be available only from:

National Technical Information Service
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Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

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