WATER TREATMENT PLANT PROCESS CONTROL BY MEASURING FILTER EFFLUENT TURBIDITY

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ABSTRACT

The Alexandria Water General Authority (AWGA) operates and maintains six water treatment plants to produce potable water for Alexandria, the North Coast to Mersa Matruh, and parts of Beheira Governorate. Surface water is treated by aluminum sulphate (alum) coagulation, flocculation, sedimentation, filtration, and chlorine disinfection. Annual production in Fiscal Year 1999/2000 averaged 1.95 million cubic meters per day.

AWGA has set goals for turbidity for clarified and filtered water. These goals pertain to water inside the Water Treatment Plant (WTP). Outside the water treatment plant, in the distribution system, AWGA continues to meet or do better than Ministry of Health Standard of 5 Jackson Turbidity Units.

Each day at AWGA WTPs, chemists measure the turbidity of water from each individual clarifier and from each individual filter. The WTP Manager reviews this data and uses it to make process control decisions about chemical dosage and filter backwash.

This paper explains AWGA's Turbidity Goal for filtered water, presents recent data, and describes how WTP managers use this data for process control. Any water treatment plant in Egypt can use these procedures. The results can be better process control and higher quality water.

INTRODUCTION

The World Health Organization (WHO) says:

> "The fundamental purpose of water treatment is to protect the consumer from pathogenic microorganisms and impurities in the water that may be offensive or injurious to human health."

WHO presents the concept of a four-stage multiple barrier system for removal of microbiological contamination:

1. Watershed Protection
2. Coagulation, Flocculation, and Sedimentation
3. Filtration
4. Disinfection

Measuring coliform bacteria is the most common laboratory test used to verify that treated water is free of microbiological contamination. However there are two problems with this test. First the time it takes to get results: 24 hours using membrane filter (MF) technique or up to 96 hours using multiple tube fermentation techniques (MTFT). Second problem is that this only measures bacteria. Another test is needed to measure pathogenic protozoa such as *Giardia* and *Cryptosporidium*.

Since determining the exact concentration of harmful microbes is difficult, time consuming, and expensive, it is easier and safer to:

(1) Assume their presence
(2) Operate the WTP effectively in order to eliminate them
(3) Measure indicators of treatment effectiveness such as turbidity and chlorine residual.

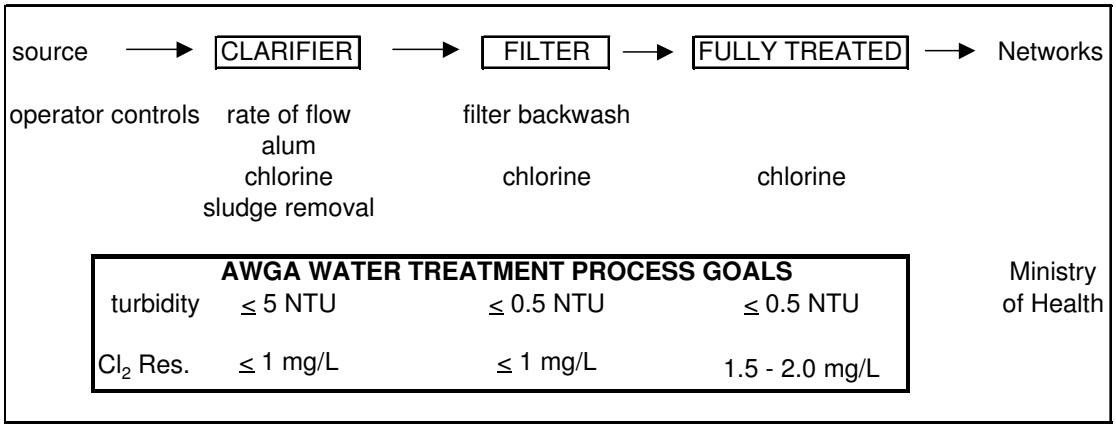
AWGA'S WATER TREATMENT GOALS

In August 2000, AWGA approved treatment goals for clarified and filtered water at its operating water treatment plants. These goals are for processes inside the treatment plant.

In selecting treatment goals, AWGA considered these factors:

1. Usefulness as an indicator of process control
2. Speed and ease of measurement
3. Importance to public health.

Based on these factors, AWGA set treatment goals for turbidity and chlorine residual for its water treatment processes.



IMPORTANCE OF TURBIDITY REMOVAL

(1) health: turbidities > 1.0 NTU interfere with chlorine disinfection
(2) appearance: no one wants to drink water containing visible particles
(3) process control: effectiveness of clarification and filtration is measured quickly, easily, and inexpensively by turbidity

WHO & USA RECOMMENDATIONS FOR FILTER TURBIDITY

WHO recommends that filtered water have turbidity ≤ 1 NTU in order to reduce interference with disinfection. In the United States, the standard is 0.1 NTU turbidity achieved 95% of the time based on the maximum value recorded during 4-hour time increments. This results in about 180 turbidity readings per filter per month, of which 170 should be ≤ 1 NTU.

PAST PRACTICE AT AWGA

Past practice for filter effluent turbidity was to measure turbidity of combined filters and from the clearwell. These were averaged and a single turbidity value reported for the water treatment plant for the day. This kind of averaging is simple but it can hide the problems of individual filters. A malfunctioning individual filter could allow the passage of sufficient microbial contamination to threaten public health despite the plant as a whole producing low finished water turbidity.

PROCEDURE

Once each day, AWGA WTP Laboratory staff collects a sample from each filter's effluent line, measure turbidity in the laboratory using a Hach turbidimeter calibrated with Gelex (secondary) standards, and record results. The results are given to the WTP Manager who investigates turbidity values ≥ 1.0 NTU, and as needed stops a filter and backwashes.

RESULTS

Results can be summarized in a table but it is easier and faster to understand in a graph. Table 1 summarizes daily turbidity readings for the 43 filters at Manshia WTP. Figure 1 shows the percent of readings that reach a particular turbidity value. For December 2000, there were 1030 readings of which 86% are ≤ 0.5 NTU and 98% are ≤1.0 NTU. Figure 2 shows the % readings for the period October 2000 through January 2001 for Manshia WTP.

AWGA uses the computer software spreadsheet program Microsoft Excel to tabulate and graph data. A computer makes data analysis easier, but it is possible to do this manually. See Table 2 for the manual procedure.

DISCUSSION

The data show individual variations among filters for the same day. When we reported only one value for the WTP we did not see this so clearly. The WTP Manager studies the results to understand what caused the high turbidity reading. For example, during November and December some high turbidity readings were caused by stoppage of the aluminum sulphate chemical feed system due to electrical power outages.

CONCLUSIONS AND RECOMMENDATIONS

Turbidity is a fast, easy, inexpensive parameter to measure. Measuring turbidity from each filter each day provides the WTP Manager with useful data for process control, specifically to evaluate the effectiveness of the clarification and filtration processes and to determine when to backwash the filter. A computer makes data recording and analysis easier but it is possible with only a pocket calculator, pencil, and graph paper.

For AWGA the next steps are to install on-line analyzers that will provide continuous turbidity measurement.

Table 1. Daily turbidity readings for the 43 filters at Manshia WTP

	1-Dec	2-Dec	3-Dec	4-Dec	5-Dec	6-Dec	7-Dec	8-Dec	9-Dec	10-Dec	11-Dec	12-Dec	13-Dec	14-Dec	15-Dec
Total	40	40	39	39	40	39	38	38	33	37	34	36	33	27	
<0.501	28	29	32	19	30	26	38	30	31	37	33	28	25	24	
<0.801	37	33	34	26	37	36	38	37	32	37	34	31	30	27	
<1.01	40	37	36	34	39	39	38	37	33	37	34	35	32	27	
<0.501	70%	73%	82%	49%	75%	67%	100%	79%	94%	100%	97%	78%	76%	89%	
<0.801	93%	83%	87%	67%	93%	92%	100%	97%	97%	100%	100%	86%	91%	100%	
<1.01	100%	93%	92%	87%	98%	100%	100%	97%	100%	100%	100%	97%	97%	100%	

	16-Dec	17-Dec	18-Dec	19-Dec	20-Dec	21-Dec	22-Dec	23-Dec	24-Dec	25-Dec	26-Dec	27-Dec	28-Dec	29-Dec	30-Dec	31-Dec
Total	35	35	34	35	36	32	32	32	31	36	32	32	34	34	28	19
<0.501	24	28	31	35	30	30	31	31	31	34	30	27	34	34	28	18
<0.801	32	32	34	35	34	30	32	32	31	35	31	31	34	34	28	19
<1.01	35	33	34	35	36	32	32	32	31	36	32	32	34	34	28	19
<0.501	69%	80%	91%	100%	83%	94%	97%	97%	100%	94%	94%	84%	100%	100%	100%	95%
<0.801	91%	91%	100%	100%	94%	94%	100%	100%	100%	97%	97%	97%	100%	100%	100%	100%
<1.01	100%	94%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

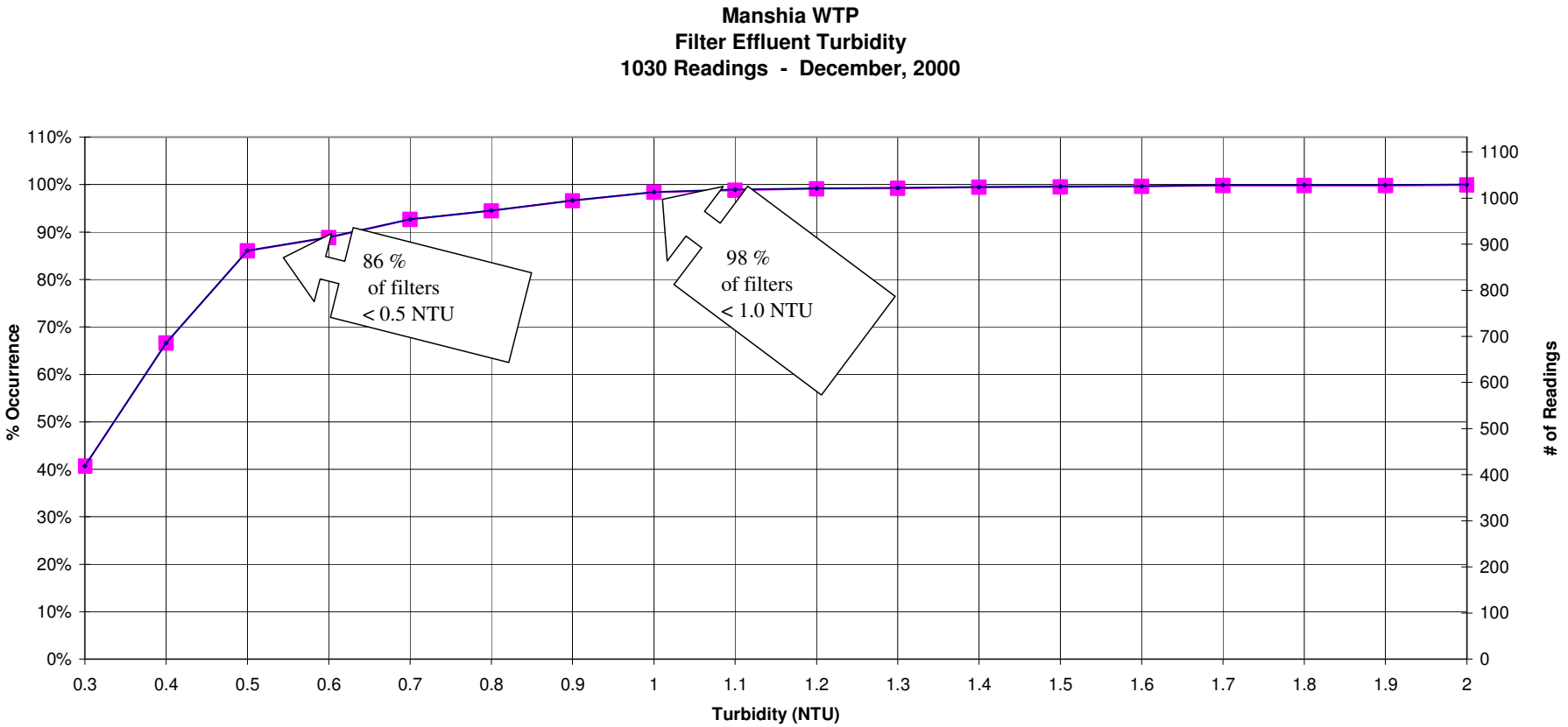


Figure 1. Percent of readings that reach a particular turbidity value

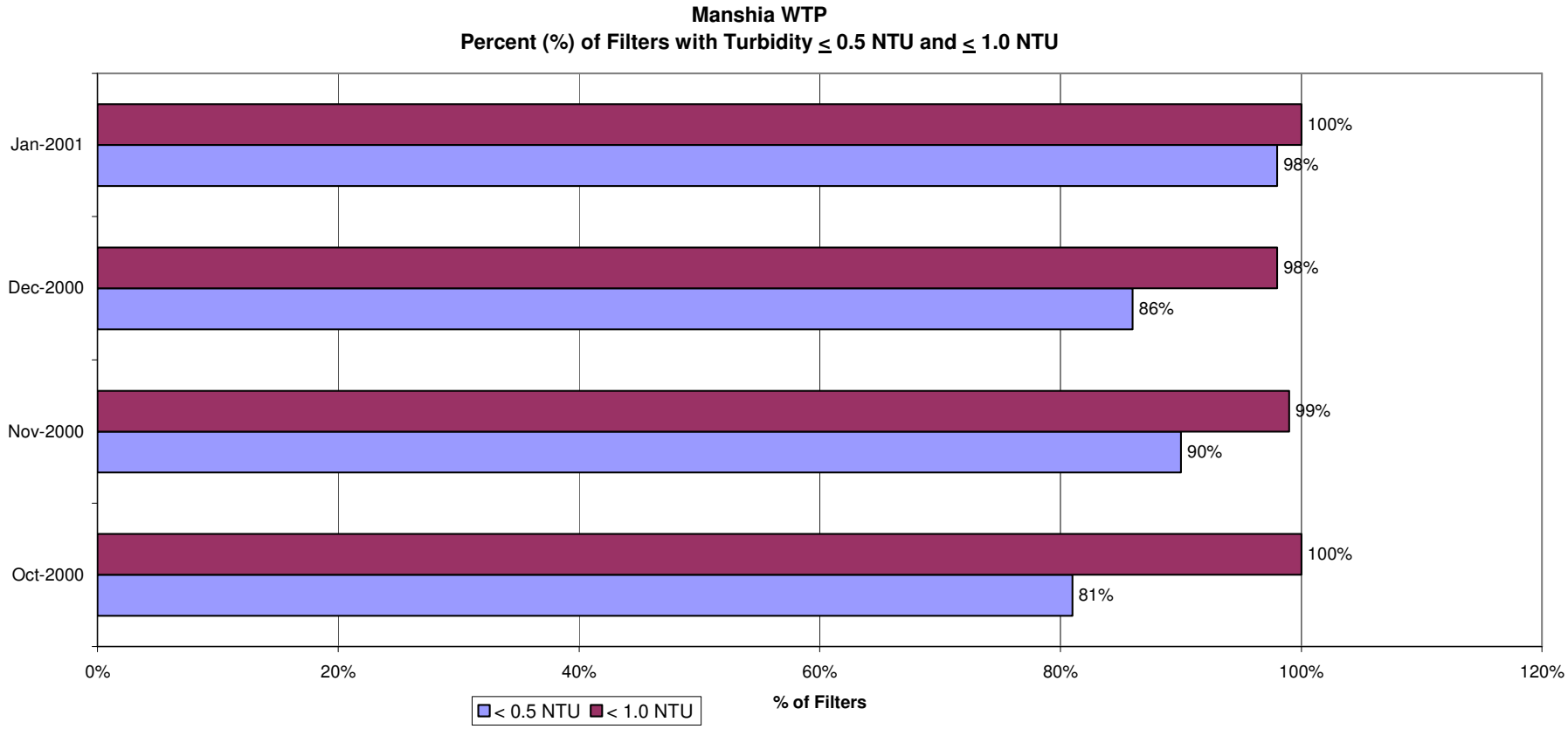


Figure 2. % readings for the period October 2000 through January 2001 for Manshia WTP

Table 2: Procedure for Analyzing Data without Computer

1 Record turbidity of filter effluent for each filter for each day

2 Group the number of occurrences according to ranges
then count and calculate the percentage for each range

range	no. of readings	% of total readings
0.0 to 0.50		
0.51 to 0.60		
0.61 to 0.70		
0.71 to 0.80		
0.81 to 0.90		
0.91 to 1.00		
1.01 to 2.0		
2.01 to 5.0		
>5.0		
	total =	total =

3 Graph range on the x axis and % of total readings on the y axis

4 Draw a smooth curve through the points