PERFORMANCE EVALUATION OF AL-DEWANYIA WATER TREATMENT PLANT IN IRAQ

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Abstract

In order to design and operate an effective water treatment system, a thorough understanding of the process of coagulation-flocculation and filtration is essential in the delivery of water of the greatest clarity and lowest possible turbidity in the finished water. This research outlines the finding of investigation of the treatment plant in Al-Dewanyia in Iraq. Performance of Al-Dewanyia Water Treatment Plant in Iraq is an essential parameter to be monitored and evaluated to better understanding of design and operating difficulties in water treatment plants. The conclusions of these evaluations may determine required recommendations and highlight modification requirements for continuous design and operating schemes. The evaluation conducted in this research was carried out by reviewing the engineering design to assure matching of standards and codes. Also, physical (turbidity and TSS) , and biological, analysis were conducted to investigate water quality. The conclusions drawn from this research outlines the importance of accurate engineering design and need for continuous monitoring and analysis of each unit performance. Finished water is not conforming to World Health Organization (WHO) Standard for Drinking water.

Keywords: **Water treatment plant , turbidity, WHO, calriflaculater, filter, water quality**

تقيم أداء محطة معالجة مياه الشرب في مدينـة الديوانية

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الخلاصة

لتصميم و تشغيل محطات معالجة مياه الشرب بكفاءة عالية، يتطلب أدراك شامل لعمليات و مراحل معالجة مياه الشرب من تخثير، تلبيد و ترشيح لغرض أنتاج مياه صالحة للشرب و تقليل العكورة إلى أدنى حدود مسموحه. يلخص هذا البحث تقيم أداء محطة معالجة مياه الشرب في مدينة الديوانية في العراق. يعتبر تقييم أداء محطة معالجة مياه الشرب في مدينة الديوانية عامل ضروري و مهم لمراقبة و تقيم و فهم صعوبات التصميم و التشغيل لمحطات معالجة مياه الشرب في العراق لان معظم محطات المعالجة في العراق لها نفس التصميم الهيدروليكي ومصدر المياه هو النهر (مياه سطحية) و لكن تختلف في مقدار التدفق. في هذا البحث تم تقييم التصميم الهندسي

لمحطة المعالجة لغرض التأكد من مطابقته للمحددات التصميمية. و لغرض تقييم نوعية الماء الناتج من المحطة تم قياس العكورة، المواد الصلبة العالقة، و الملوثات الحيوية في مختبر محطة المعالجة. و من أهم نتائج هذه الدراسة هو وجوب الاهتمام بتصميم محطات المعالجة و المراقبة المستمرة لمراحل المعالجة و تحليل أداء كل مرحلة. ان نوعية الماء الناتج ن محطة المعالجة لا يتوافق مع معاير ومحددات منظمة الصحة العالمية لمياه الشرب.

Introduction

Al- Dewanyia Water Treatment Plant in Iraq (DWTP) was built in 1973. The untreated water is pumped from the Al-Dewanyia River to the DWTP by five large pumps and is then dispatched into flash mixer. The water then flows through a four calriflaculaters (flocculation, and sedimentation tank) and filtered through a sand bed (20 unit) as shown in **Figure** 1. After chlorination, the water is stored in two underground reservoirs (clear well). Five booster pumps, connected to the last reservoir, ensure the water supply in the Al- Dewanyia city network.

In this study a water treatment plant, DWTP, was investigated from all aspects and considerations including; engineering, chemical, biological, and bacteriological to determine water treatment plants efficiency and produced water quality. This study will define design and operating problems and difficulties for this case study. That will allow for proper revision of these aspects to define the suggested recommendations to be considered in designs and operating conditions. The findings of this research may be applicable for other WTPs either under design or under operation.

Previous literature have recorded water treatment plants difficulties including problems associated with filter operational problems such as air binding and negative head due to algae respiration and filter media cracking. Also, the handbook of the water quality prepared by the AWWA, 1971 [1] have illustrated other operating considerations required for proper performance such as control needed for chemical additions and analysis. ElDib [2] has illustrated in different studies the importance of continuous monitoring and analysis laboratory works to evaluate performance before and after each treatment unit. When online, a periodic review of plant performance is undertaken to ascertain if, or otherwise, the plant works according to prediction. Hammer [3] and Cairncross [4] both agree that record–keeping and periodic reviews of plant performance are necessary decision tools when the plant requires expansion or when operational problems arise.
The purpose of the study is to evaluate the performance of existing water treatment plant in Al-Dewanyia city with a view to identifying the gabs/ inadequacies (if any) regarding quality of water used and supplied after treatment including performance of all treatment process. It is well-neigh appreciated that the operation of the system mainly suffers due to lack of systematic approach and co-ordination

Material and Method s

1. Experimental Work

Providing cleaner water to the consumers also reduced maintenance demands as less routine flushing is required of the mains reticulation system. The higher turbidity levels previously resulted in sludge build up in the mains which reduced the quality of the water that reached the consumers and also affected the chlorine residual levels throughout the reticulation system. In Al-Dewanyia in Iraq, the DWTP, meeting seasonal water demands, provides water to the city, and some villages around, supplying around 96 000 m^3/day serving about 300 000 consumers. The water to the Al-Dewanyia city comes from the Al-Dewanyia River (**Figure** 2) source and treatment in the Water treatment plant. As it is typical of the rivers of the Iraq, the flow is very irregular, having a high flow place in the months of December to April and a Low flow in the remain months.
The surface water from Al-Dewanyia River very often contains suspended clay, sand and lime particles, various organic dissolved solids and other materials, which manifest themselves as turbidity, dissolved solids and other chemical parameters. This water has to be treated properly to make it suitable for drinking and domestic use.
Samples of turbidity were collected from intake and from all WTP's units where full analysis were carried out in the laboratory of DWTP. Analysis were conducted for chemical, physical, bacteriological analysis. All experiments were done and results were determined in accordance to the Standard Methods (APHA) [5].
In order to assess the performance of the water treatment plant in terms of water quality, turbidity measurements were taken between unit water treatment processes during experiments. The outlet measurements were compared to water quality standard values. Also in DWTP there is no monitoring system to measure different chemical parameters.
Water turbidity was measured with the portable turbidimeter HACH Model 2100P from January 1th, 2008 to December 31th, 2008 .
This turbidimeter operates on the nephelometric principle of turbidity measurement (scatter light ratio to transmitted light). The measuring range is 0–1000 NTU with an accuracy of +/- 2% of readings (HACH 2004). The calibration of the turbidimeter is based on three samples of standard turbidity (20, 100, 800 NTU).

Daily water samples were collected between unit water treatment processes. For high-turbidity events, measurements of the inlet turbidity and outlet turbidity were taken at least every fifteen minutes. Water samples were taken with a 1.5 L plastic bottle filled in an average of 15 s.
The performance of this design has been tested on a 96000 m3/day scale at a demonstration-scale

drinking water treatment plant, which was designed to test the various treatment process lines that consist of a combination of unit processes such as coagulation/flocculation, sedimentation, sand-filtration, and chlorination. Raw water collected from Al-Dewanyia River was used as feed water and alum was used as coagulants. Al-Dewanyia river, with high density of residence located on both sides. **Figure** 1 and Table 1 show seasonal characteristics of water quality in Al-Dewanyia River. As shown in **Figure** 3, target compounds in Al-Dewanyia River are algae, taste & odor matter, Natural Organic Matter (NOM), disinfection by-products (DBPs) and micro pollutants. Table 2 shows the comparison of water quality criteria between Iraq and US.EPA. Especially, domestic water quality is minimal requirement to meet present regulation, but drinking water treatment process is practically managed to meet the target water quality value which considered the reinforced water quality criteria and target compound concentration in Al-Dewanyia River.

2. Process Description

In order to design and operation an effective water treatment system, a thorough understanding of the process of coagulation-flocculation and filtration is essential in the delivery of water of the greatest clarity and lowest possible turbidity in the finished water. Clarity also aids filter operation by reasonably long filter runs. The aggregation step. A cousin system of the solids contact basin consists of a sedimentation zone inside an annular clarification section. Filtration is the final and most important solid-liquid separation step in potable water treatment. The following gives a brief description of all DWTP units components facilities.

Intake

Coarse bar screen along with two pipe conduits each of 800 mm diameter collects raw water to a raw water sump of 240 m^3 volume. This can maintain a minimum retention time of about 8 minutes at low water level of the canal and up to 13 minutes retention at high water level. The intake is located about 300 m away from the location of the treatment plant (**Figure** 4).

Prechlorination

A prechlorination dose of about 3.5 mg/L along with 35 mg/L alum dose are added at the distribution chamber inside the treatment plant and directly prior to coagulation process. Alum is added as a solution of 10% concentration (**Figure** 5).

Coagulation and Sedimentation

The raw water is coagulated continuously with aluminum sulphate in flash mixer tank of 13.3 3 m^3 with a retention time of 22 seconds. Next, the water flows through the 4 clariflocculator of 38 m diameter (clarifier) with a retention time of 1.5 hr and 14 m diameter of flocculater with a retention

time of 18 minutes and arrive to twenty rapid filters. also, surface loading rate of 42 $m^3/m^2/d$ was maintained (a higher loading rate limit) (**Figure** 6).

Sand Filters

Twenty filters are used, flow of each is about 83 L/s (eighteen are working and two for washing). Surface area of each is 42.5 m^2. The rate of filtration was found to be about 235 $m^3/m^2/d$, while standard is to be about 120-180 $m^3/m^2/d$. Sand analysis were conducted on sand samples and it was found that the effective size of the sand is about 1.2 mm, where the standard is 0.45 to 0.55 mm. This shows that sand used inside filters is coarse. Also, uniformity coefficient was found to be 2, where standard is 1.75 to 2. This also proves that sand used is a coarse media and out of the standard limits (**Figure** 7) .

Storage and Other Facilities

The plant contains ground and elevated storage tanks with insufficient capacities, however, this is not the objective of this work, It should be highlighted that proper volume should be maintained for storage capacity. Also, the plant was found to contain all auxiliary buildings such as pumping units, sludge tanks, stores, workshop, laboratory and all others.

Results and Discussion

The experiments were carried out in the water treatment plants supplying Al-Dewanyia (Iraq) from Al-Dewanyia River. The water is treated with traditional

processes like coagulation Flash Mixing, flocculation, sedimentation (Clariflocculator), filtration and disinfections.
Turbidity was measured between unit water treatment processes during experiments. Table 3 includes turbidities between unit processes. The **Figures 8 , 9**, and **10** present turbidity for samples taken between processes. As we supposed, no reduction and even increase of turbidity were observed after flocculation. Higher hydration of flocs after flocculation caused to increase of total suspended particles volume.
Monthly turbidity measurements are shown in **Figure** 8. The maximum turbidity recorded (raw water) is about 200 NTU (as shown in **Figure** 3) but a lot of rain events were measured. On sunny days, the turbidity was about 60 NTU. The **Figure** 8 shows the water quality of DWTP (Turbidity) before and after treatment in summer and winter. As stated on all analyses received since treatment started “This water complies with the recommended guidelines [WHO] for drinking water quality.”
The most important increasing of turbidity were noticed after sedimentation. Flocculated particles were not effectively reduced in sedimentation tank. Turbidity increased about 30 times. It could be explained by proportionally lower volumetric decrease of fine particles in total suspended solid volume than bigger particles after sedimentation. Probably, some big, strongly hydrated flocs

characterized by small density settled too slowly to stop in sedimentation tank. Such big particles like these should not inflow to the filters, because they block upper pores of sand media (but the big particles are inflow to filter). Filtration reduces nephelommetric turbidity from 30 to 50, not guaranteeing lower value than standards.
Results presented in Table 2 show lower removal efficiency of sedimentation and filtration processes predicted base on nephelometric turbidity.

The turbidity variations are as represented in **Figure** 11 higher effluent turbidity values were recorded during August 2008, higher effluent turbidity values (≈35- 40 NTU) were observed during the August 2008. This could be due the increase with regards to consumption for the homes.
The experimental work has indicated that turbidity of raw water was in the range of 130-60 NTU, with TSS. of 56-82 mg/L. Also, the analysis has indicated a total bacterial count of 140 to 11 x 10^2 with high values in August. Algae total count was found to be in the range of 686 to 694 organism/mL, Diatoms, green and blue green algal groups were all found.
Through treatment processes, the turbidity was reduced to about 20 to 30 NTU at the effluent ground water tank. The microscopic investigation of the scum formed on top layers of the coagulation tank shows high concentrations of algae, while chemical analysis shows high concentration of alum. This reflects the need for precise

determination of alum dosage and application of proper mixing as driven in the engineering evaluation. **Figure** 12 show microscopic of scum in coagulation tanks.
The objective of this case study in this research is to outline different operating and design problems found in the treatment plant and to define the conclusions for modifications and considerations.
Al-Dewanyia plant is suffering from a main malfunctioning in the coagulation tanks. **Figure** 13 shows the phenomenon observed where about 30-cm thick scum is accumulated at top of these tanks daily. That requires routine daily removal of this layer. Also a similar thickened layer settled at bottom of the coagulation tanks. Analysis conducted has indicated that raw water is highly polluted by organic matter, bacteria, and algae.
At the intake works, the raw water sump has a large volume yielding about 8 to 13 minutes retention time, while standard is to be about 2 to 5 minutes. The raw water sump was found to have sediments at bottom and full of organic
pollution. The pumped raw water to the coagulation tank (flash mixer) with these conditions allows further increase in suspended matters. The laboratory analysis still indicated the existence of organics in the coagulation tank. The study recommended minimization of retention in raw water sump by minimization of volume, to prevent sedimentation, either by recirculation for complete

mixing or by dividing the sump into two chambers. Since the raw water sump is about 300 m away from the plant site, pre-chlorinating is not a desired solution for bacterial and algal. Also, retention time was more than needed in raw water sump, flash mixer , clarifier and flocculater which affected negatively treatment performance. Filters were found to have sand out of standards for effective size. It was concluded also that neat design is always recommended.

Conclusions

The conclusions that can be drawn from these engineering and laboratory investigations can be summarized as follows:

1. Finished water is not conforming to WHO Standard for Drinking water
2. Performance of WTP Units are not satisfactory
3. Rapid sand filters sand should be according to standards.

4. Continuous maintenance and analysis will lead to precise evaluation of plant performance and definition of any required modifications.

Acknowledgements

The authors wish to thank the Al-Dewanyia Water Treatment Plant staff for accessing to the
required data.

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Table 1. Seasonal Characteristics of Water Quality and Limitation of Water Treatment

Season	Water Quality Pattern	Limitation
1~3 month	NOM ↑, M ro r	Po ll s↑ Mixing/Coagulation Performance Decrease
3~6 month	Algae ↑, T s & o r M pH ↑, R s l Chlo r	r ↑ DBPs ↑ (Chlo r Do s I r s) Co ↑ Mixing/Coagulation Performance Decrease
6~9 month	Turbidity ↑ Alkalinity ↓	Filtration Bachwashing Interval Decrease Coagulant and pH Controller Increase

9~12 month	Algae ↑ NOM ↑, DBPs ↑	DBPs ↑ (Chlo r Do s I r s) Claim ↑(T s & o r M r)

Table 2. Comparison of Water Quality Criteria between IRAQ and US.EPA

Items		**Water Quality Criteria**	**Water Quality Target Value**	**US.EPA Criteria**
Taste & Odor	Sensory Evaluation	No Taste/Odor	<3TON	<3TON
	Geosmin, MIB	-	<10ng/L	-
Pathogenic Microbes	Giardia	3 log	5 log	5 log
	Cryptosporidium	-	3.5 log	3 ~ 3.5 log
	Turbidity	5 NTU	0.1NTU	0.1NTU
	Particles	-	50/mL	-
Disinfection By-Products (DBPs)	TOC	-	35% Removal	15 ~ 50% Removal
General Items	NH4+	0.5㎎/L	0.5㎎/L	-
	Fe	0.3㎎/L	0.3㎎/L	0.3㎎/L
	Mn	0.3㎎/L	0.05㎎/L	0.05㎎/L
	pH	5.8 ~ 8.5	7.5 ~ 8.0	6.5 ~ 8.5

Table 3 Nephelometric turbidity (average) between each of the unit processes

Unit process	**Raw water, before Coagulation**	**After Flush Mixing**	**After Clariflocculator**	**After Rapid Filtration**
Turbidity [NTU]	75	70	40	20

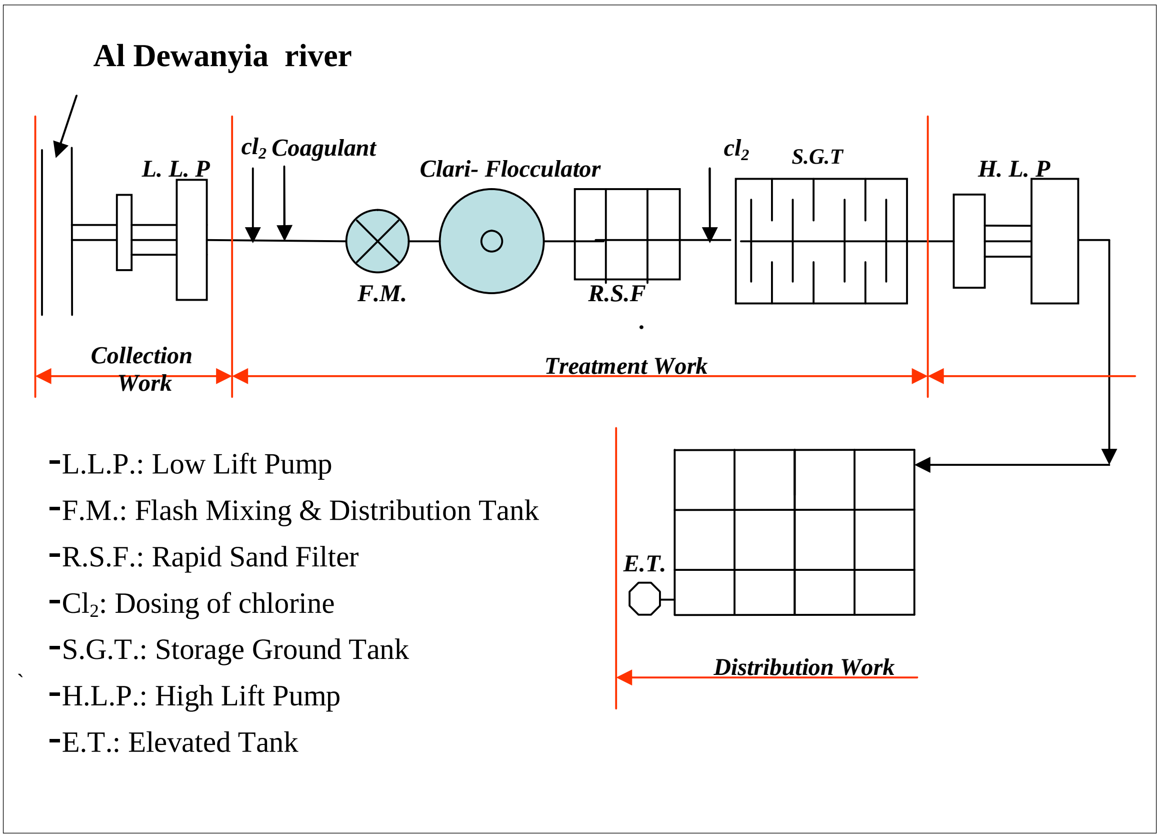

Figure 1. Al-Dewanyia WTP layout

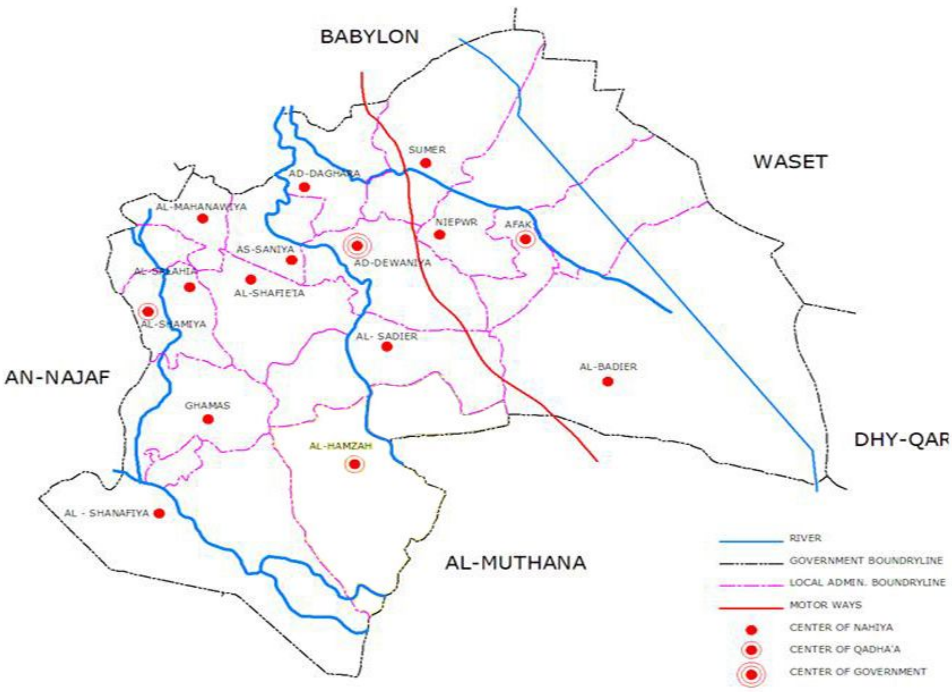

Figure 2. Al-Dewanyia Rivers Map

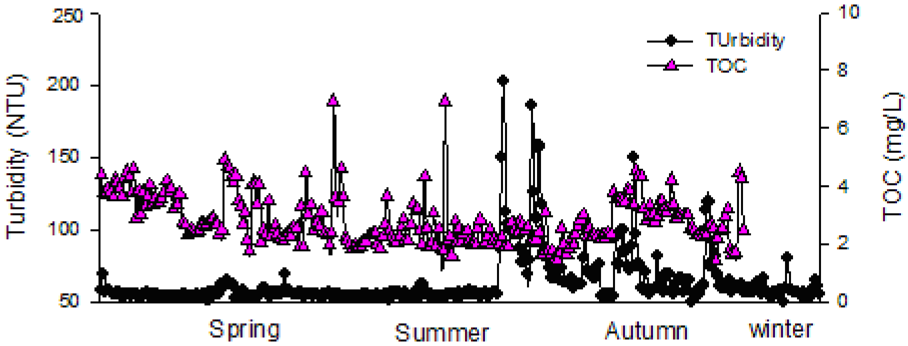

Figure 3. Seasonal Characteristics of Raw Water Collected from Al-Dewanyia River

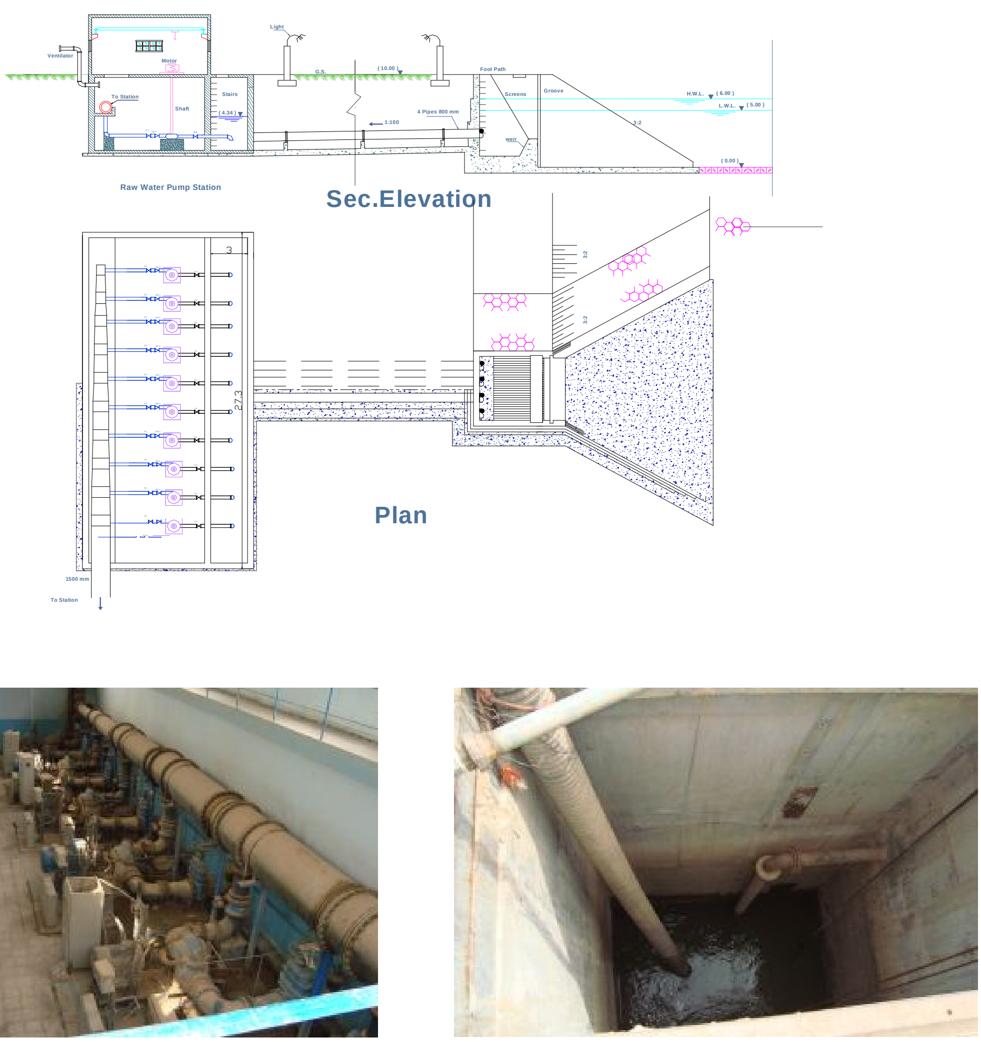

Figure 4. Shore Intake

Figure 5. Prechlorination dose

Figure 6. Coagulation and Sedimentation

Figure 7. Sand Filters

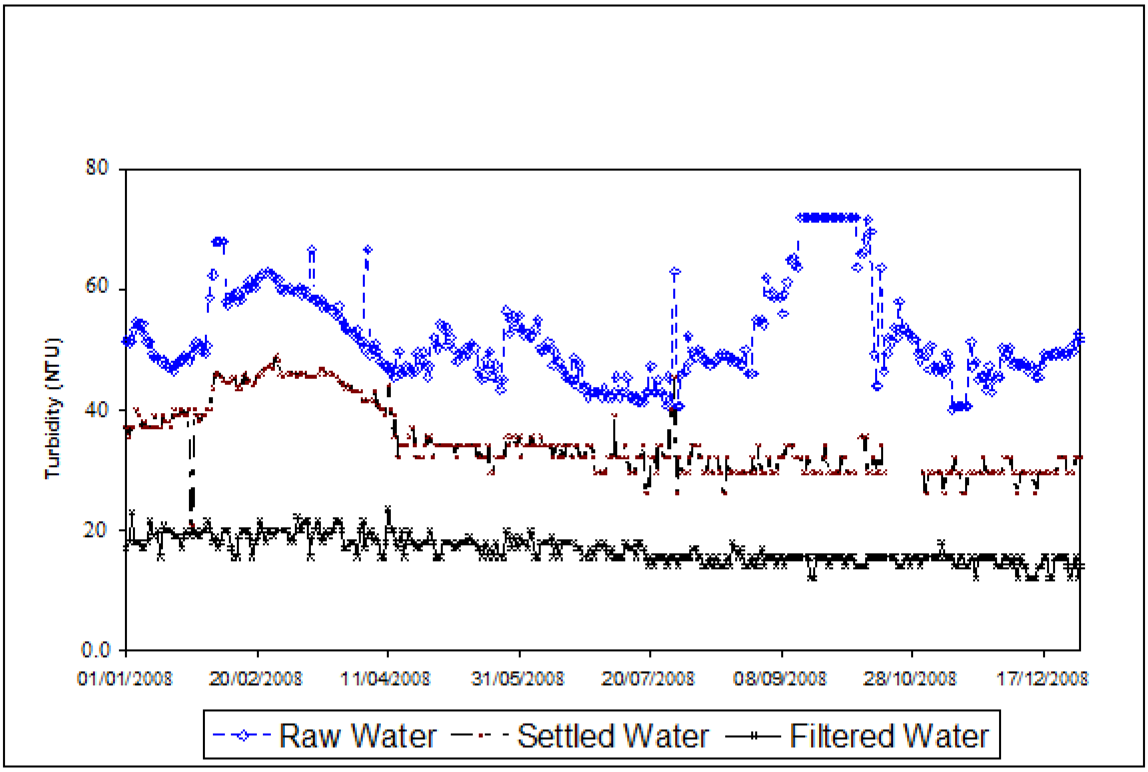

Figure 8. Monthly Turbidity Measures from January 2008 to December 2008

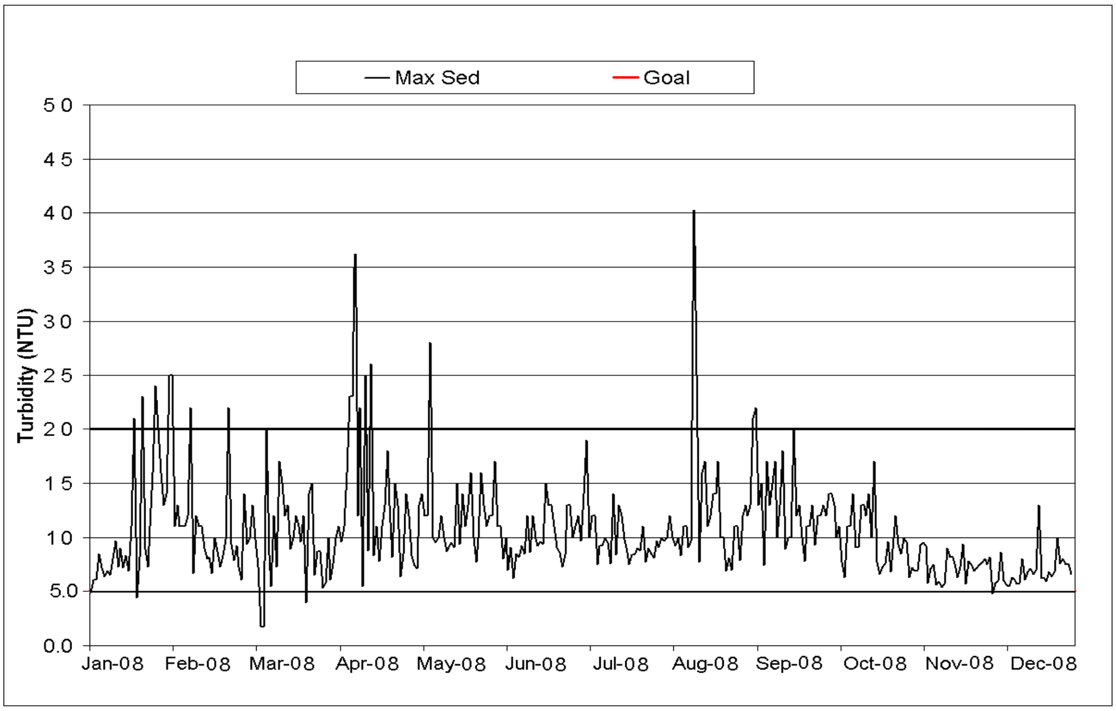

Figure 9: Turbidity Variations in Treated Water after sedimentation tanks

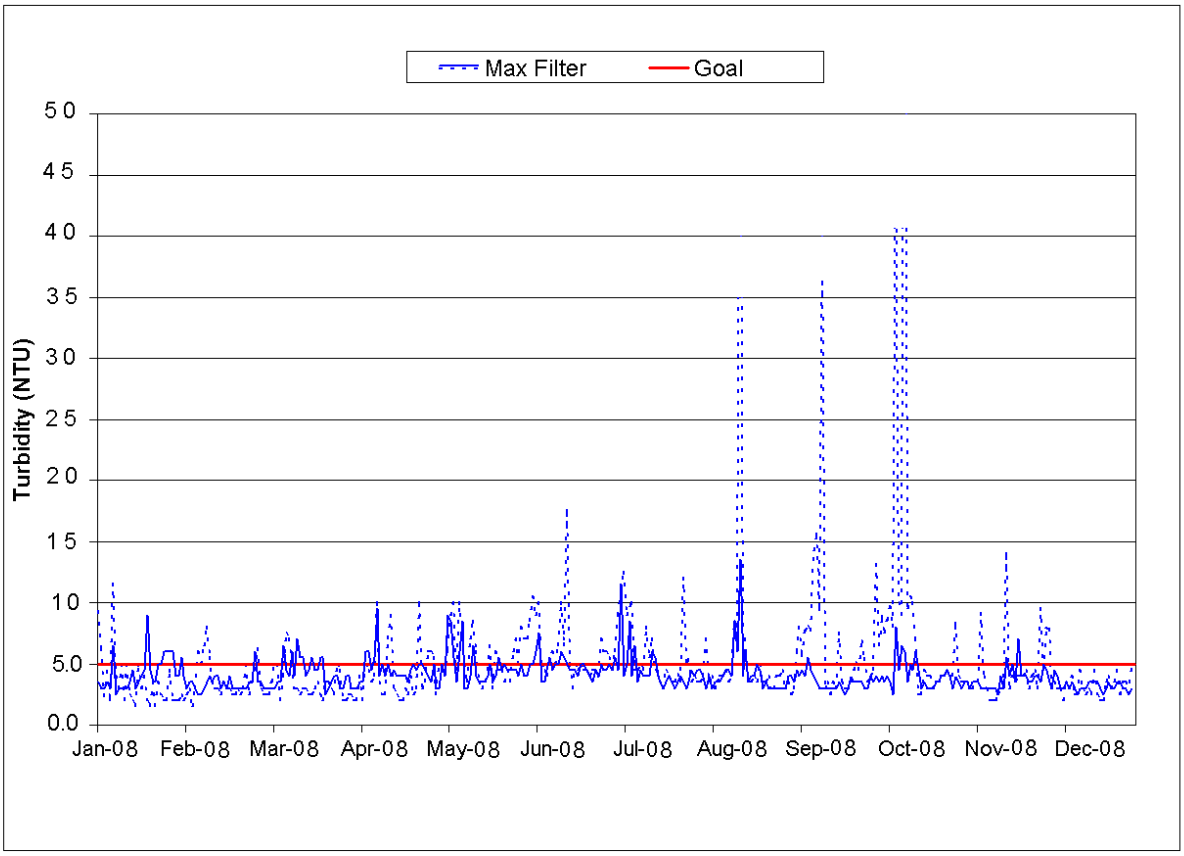

Figure 10. Turbidity Variations in Treated Water after filter tanks

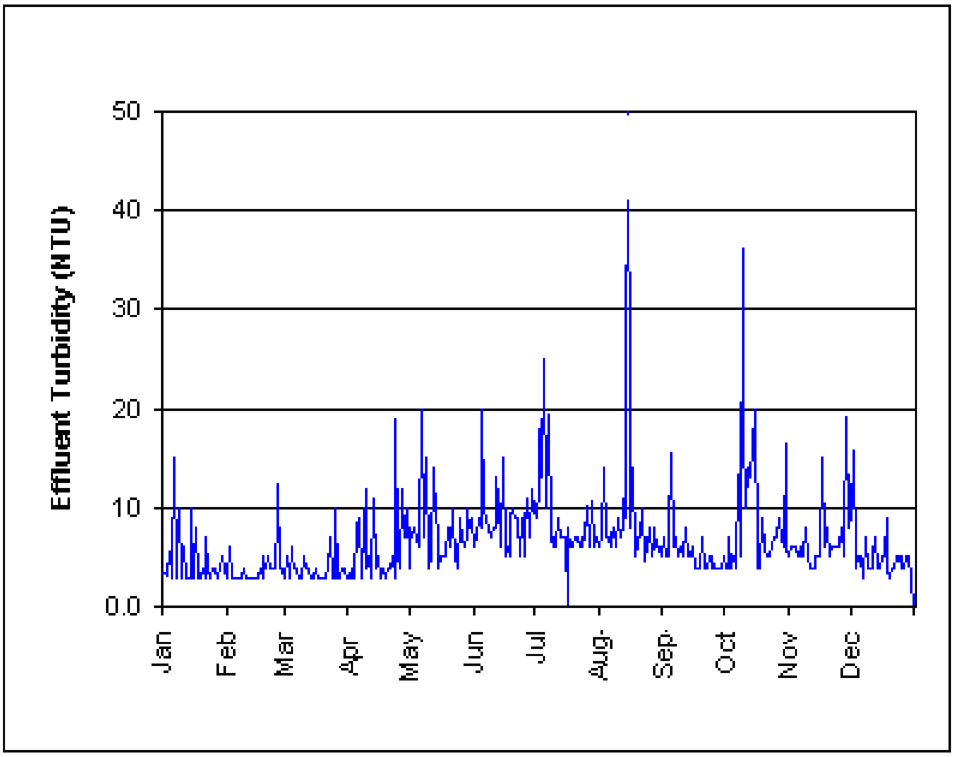

Figure 11: Turbidity Variations in Treated Water in 2008

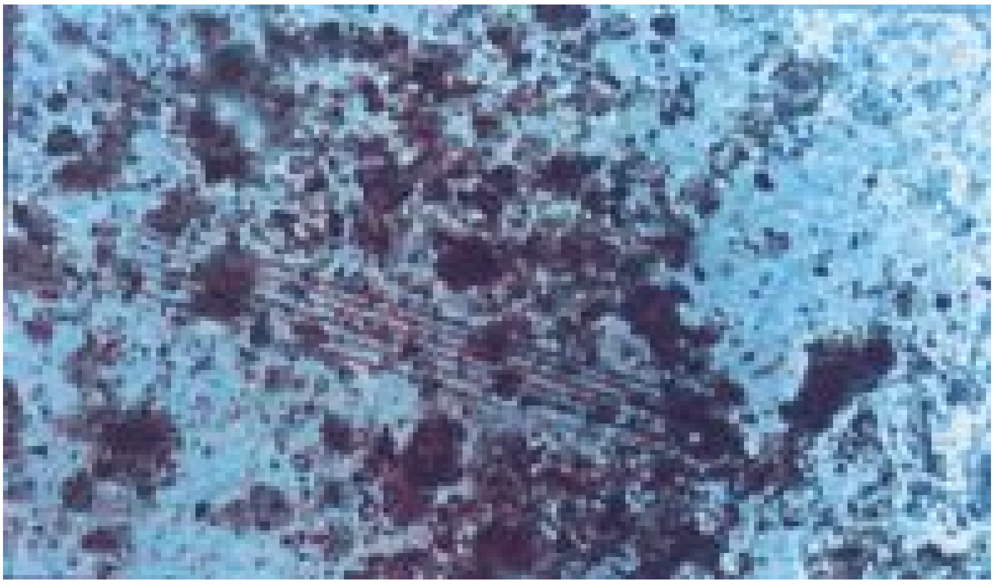

Figure 12. Microscopic of scum in coagulation tanks.

Figure 13. The phenomenon observe where about 30-cm thick scum is accumulated at tank

NONLINEAR DYNAMIC ANALYSIS OF LAMINATED COMPOSITE PLATES UNDER IN-PLANE COMPRESSIVE LOADS

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Abstract

A nonlinear finite element method is adopted for the large displacement elastic-plastic dynamic analysis of anisotropic plates under in-plane compressive loads. The analysis is based on the two-dimensional layered approach with classical and higher order shear deformation theory with five, seven, and nine degrees of freedom per node, nine-node Lagrangian isoparametric quadrilateral elements are used for the discretization of the laminated plates. Both consistent and lumped mass matrices are used in the present study. Damping property is considered by using Rayleigh type damping which is linearly related to the mass and the stiffness matrices. **Newmark** integration method is used for solving the dynamic equilibrium equations. The effects of initial imperfection, orthotropy of individual layers, fiber's orientation angle, type of loading, damping factor, and fiber waviness on the large displacement elastic-plastic dynamic analysis are considered. The conclusion it is shown that the antisymmetric cross-ply laminated plate has a damping rate faster than the symmetric cross-ply laminated plate and if damping is considered and if the response of the plate shows no oscillation about the static deflection position, it means that the damping factor is below the critical damping factor.