EVALUATION OF A WATER TREATMENT PLANT PERFORMANCE – CASE STUDY

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ABSTRACT

With the increasing intrest and care of the governoment of Egypt to the importance of the field of water production and supply, many new water treatment plants were either constructed or extended during the past few years. Performance of these plants 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. This research outlines the finding of investigation of the treatment plant in Dakahlia (Meet Fares). The evaluation conducted in this research was carried out by reviewing the engineering design to assure matching of standards and codes. Also, biological, chemical and bacteriological 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.

INTRODUCTION AND OBJECTIVES

A water treatment plant, Meet Fares of Dakahlia, WTP, was investigated from all aspects and considerations including; engineering, chemical, biological, bacteriological, organic pollutants, trihalo methane and heavy metals 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 WTP 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 [1]. Also, the handbook of the water quality prepared by the AWWA, 1971 [2] have illustrated other operating considerations required for proper performance such as control

needed for chemical additions and analysis. ElDib [3] has illustrated in different studies the importance of continuous monitoring and analysis laboratory works to evaluate performance before and after each treatment unit.

The objective of this research is to illustrate the findings of this case study for the revision of engineering design and analysis work. The results obtained have highlighted the operating problem difficulties as well as the engineering problems with bad design. The evaluation of these results will conclude the recommendations for designs and operations, which may be strongly applied for similar working or under-design plants.

ANALYSIS WORK

Samples were collected from intake and from all WTP's units where full analysis were carried out in the laboratory of National Water Research in Cairo. Analysis were conducted for chemical, physical, bacteriological analysis. All experiments were done and results were determined in accordance to the *Standard Methods* (APHA, 1995).

MEET FARES WATER TREATMENT PLANT DESCRIPTION

Meet Fares WTP is located at Meet Fares city, Mansourah, Dakahlia governorate with a 400 l/s capacity. The shore intake is constructed on Bahr Tanah Canal.

Process Description

Figure 1 shows the general layout of the WTP, which consists of collection works, treatment and storage facilities. The following gives a brief description of all WTP units components facilities.

- Shore 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 9 minutes at L.W.L. of the canal and up to 14 minutes retention at H.W.L. The intake is located about 1.0 km away from the location of the treatment plant.

- 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.

- Coagulation and Sedimentation

Two coagulation and sedimentation tanks are used. A flash mixing tank of 13.3 m^3 volume is also used in front of each coagulation tank. Each coagulation tank is a buffle tank which consists of seven chambers each with 1.0 meter width, 3.5 m depth and total volume of 293 m^3 with a retention time of 22 minutes. The rectangular sedimentation tanks is 1440 m^3 volume each with a scrapper for removal of scum and settleables. The retention time maintained in each sedimentation tank is about 2.15 hours (within standards limits), also, surface loading rate of 42 $m^3/m^2/d$ was maintained (a higher loading rate limit).

- Sand Filters

Six filters are used, flow of each is about 80 L/s (five are working and one for washing). Surface area of each is 50 m^2. The rate of filteration was found to be about 135 $m^3/m^2/d$, 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.

- 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.

PROBLEMS DIAGNOSIS AND SOLUTION

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.

Meet Fares plant is suffering from a main malfunctioning in the coagulation tanks. Figure 2 shows the phenomenon observed where about 50-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 9 to 14 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 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 1.0 km away from the plant site, pre-chlorinating is not a desired solution for bacterial and algal.

As explained above the coagulation tank consists of seven chambers. The horizontal velocity was calculated and found to be less than 0.3 m/min. This has increased also the tendency of settling and floating of suspended matter compounds. The main problem, observed in this plant, is the thick layer on the top and bottom of the coagulation tanks. The diagnosis of this phenomenon, as described above, is attributed to the bad design of the tanks with minimum retention time and non-existence of proper flash mixing of coagulants prior to coagulation tanks. It was suggested to consider reconstructing of coagulation tanks by adding mechanical mixers. Also, retention time was more than needed in raw water sump, 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.

LABORATORY ANALYSIS

The analysis conducted by NRC has indicated that turbidity of raw water was in the range of 14-28 NTU, with TS.S. Of 83-178 mg/L. COD was found in Bahr Tanah canal to be ranging 16-100 mg/L and BOD of 10-15 mg/L. This indicates a highly polluted canal with adverse physical-chemical parameters. Also, the analysis has indicated a total bacterial count of 130 to 9.8×10^6 with high values in June. Algae total count was found to be in the range of 5184 to 5394 organism/mL, Diatoms, green and blue green algal groups were all found.

Through treatment processes, the turbidity was reduced to about 0.1 to 0.6 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. Figures 3 and 4 show microscopic of scum in coagulation tanks.

Tri-halomethane Compounds

Chlorine was added as pre-chlorine with about 3.5 mg/L and about 2 mg/L as post chlorine. Usually chlorine reacts with organic and THMs are formed. Data of results obtained, as given in Table (1) shows that THMs concentrations were found to be low through treatment processes, however increased concentration was observed after post chlorination. Generally, Total THM's was always within the range of standards.

Heavy Metals

Heavy metals H.M. were observed in intake water and final ground tank. However, it was always less than standards. It was found that H.M. concentration increases in sludge and its discharge to drains is considered a violation to environmental laws. Also H.M. was found in scum of coagulation tanks, which constitutes another problem for the disposal of this scum.

CONCLUSIONS

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

1- Adequate engineering design is essential for successful operating plant. Simple design considerations for retention time, velocity, surface loading rate and dosage must be followed.

2- Rapid sand filters sand should be according to standards.

3- Continuous maintinance and analysis will lead to precise evaluation of plant performance and definition of any required modifications.

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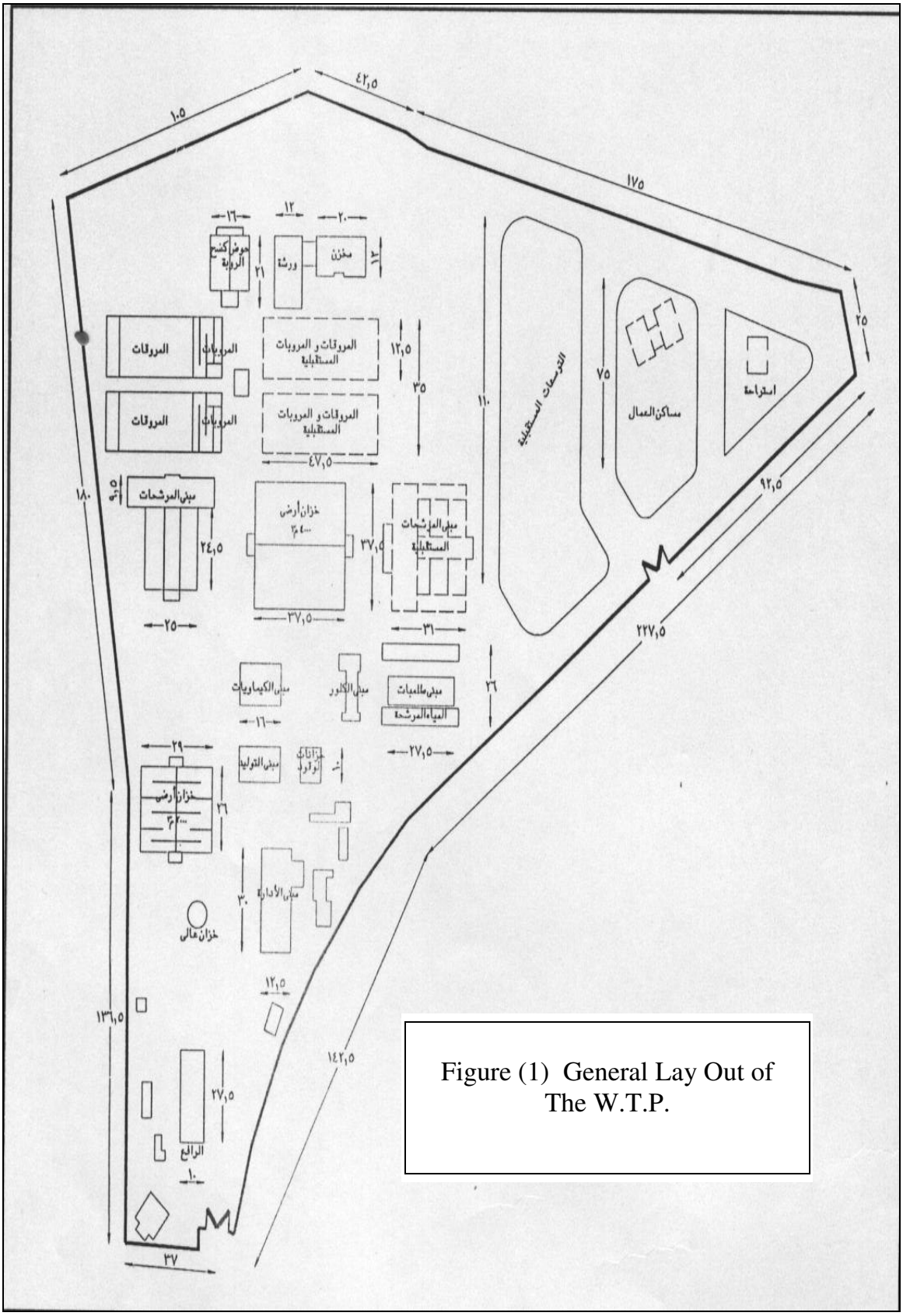

Figure (1) General Lay Out of The W.T.P.

Figure (2) The phenomenon observe where about 50-cm thick scum is accumulated at top of tanks

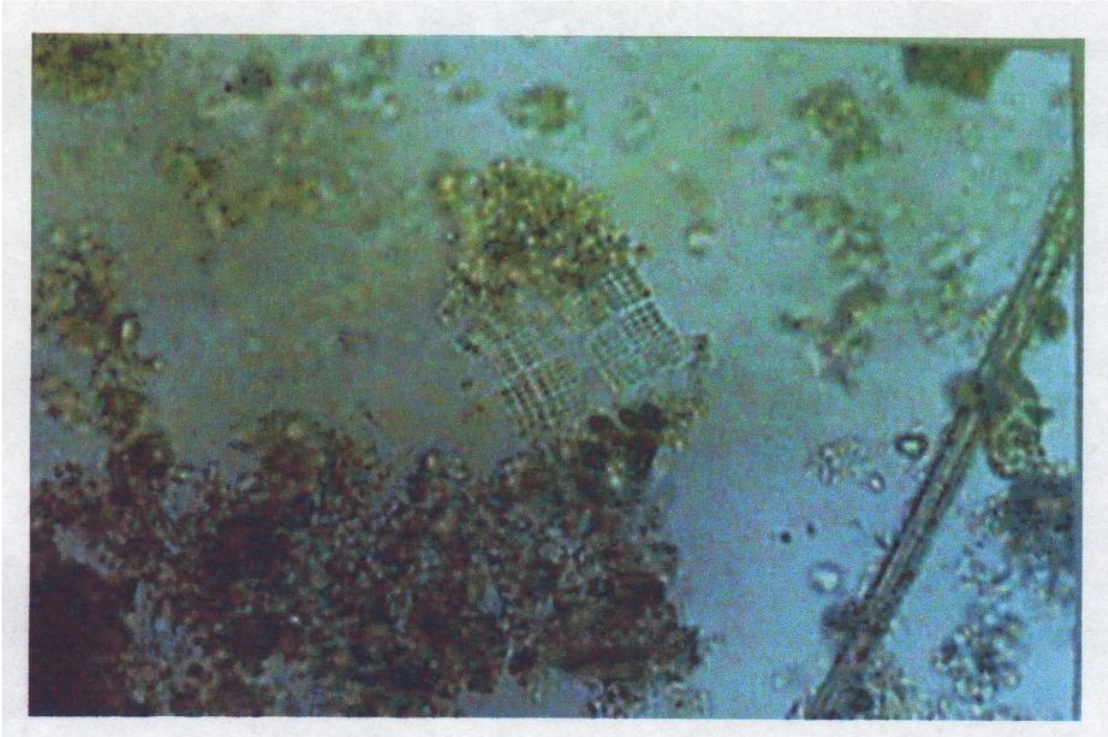

Figure (3)

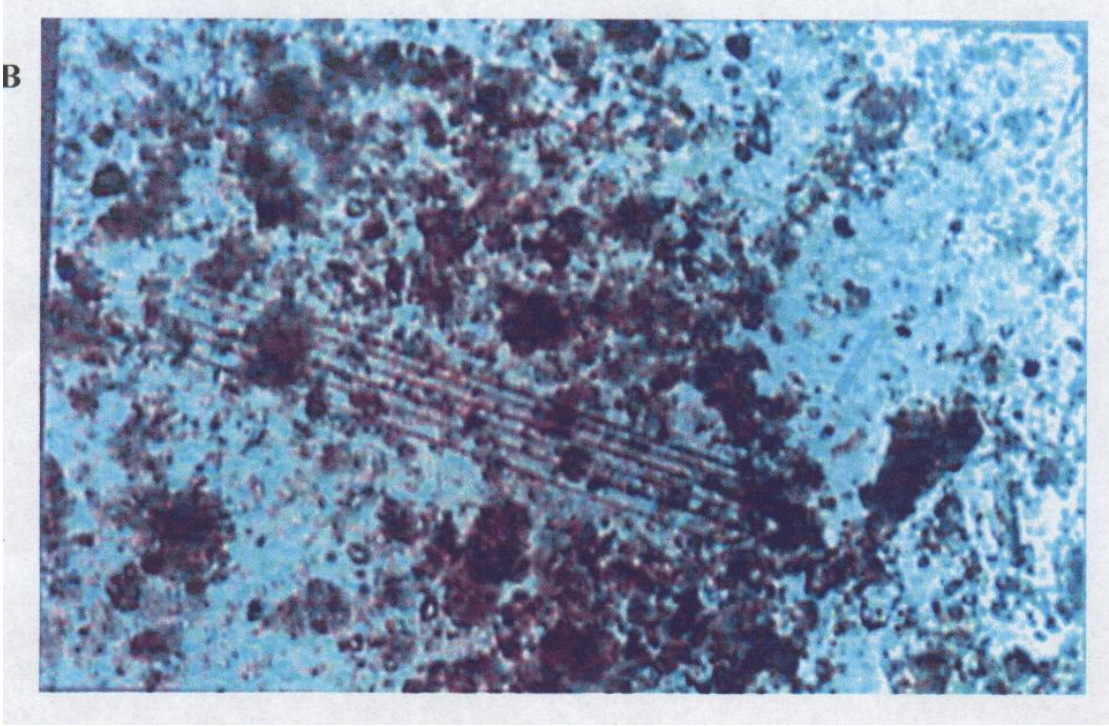

Figure (4) Microscopic of scum in coagulation tanks.