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Evaluation of the Performance of Dynamic Sand Filtration Under Real Working Conditions

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Abstract: This study reports the performance of a pilot scale, moving sand-bed filtration unit for surface water treatment. The unit with a capacity of about 7 m^3 h^{-1} was erected at the premises of Fostat water treatment plant in Cairo for the treatment of the water for potable use from the river Nile. During an observation period of 5 months, the dynamic sand filtration unit exhibited a stable performance in terms of removal of turbidity and algae and maintenance of appropriate levels of chemical agents added for aiding the treatment process (alum, chlorine). Under the same loading, the performance of the newly introduced unit was better than or comparable to that of the existing treatment unit (pulsator followed by filtration) at that site. As compared to a high turbidity of 3-14 NTU of the raw Nile water, the turbidity of the treated water was in the range of 0.2-1 NTU. The performance of the dynamic sand filtration unit, unlike that of the existing treatment unit, was not influenced by the high algae content (4000-9000 algae count) of the raw water. The algae count in the treated water was around 100. The unit also maintained, in the treated water, appropriate levels of chemical agents (alum, chlorine) which were added for treatment. The residual alum and chlorine concentrations in the treated water ranged around 0.2 and 1-2.5 ppm, respectively. The effluent from the unit convincingly conformed to the local standards.

Key words: Dynamic sand filtration, continuous washing process, water treatment technologies

INTRODUCTION

The need for a simple water treatment technique is vital for developing countries due to lack of skilled professionals. The conventional water treatment technology comprises sedimentation (with or without coagulation) followed by slow or rapid sand filtration (Viessman and Hammer, 1993). The treated water is then disinfected before supplying to the consumers. This well-established methodology is simple and nowadays with long history of applications, the operators in the developing countries are well acquainted with it.

Most of the water treatment plants in Egypt use rapid sand filtration following coagulation and sedimentation. Some of the plants use clariflocculator tank, while the other plants use pulsator as pre-treatment before filtration (El-Gohary, 1994a, b). In order to minimize the capital costs and partially the operational costs, often ‘direct filtration i.e., elimination of the sedimentation step and combination of coagulation with the filtration step is practiced. The efficiency of this technique, however, depends on the raw water quality (Janssens *et al*., 1986). In Egypt, the canals and streams

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in the Delta region are much more polluted than those in the upper region. Consequently, while the direct filtration technique may achieve acceptance in the upper regions, it may not be suitable for the highly polluted streams in the lower regions.

This study explored dynamic sand filtration (moving bed sand filtration achieving flocculation and filtration in one reactor) for treatment of surface water. This technique has been commercially applied for about a decade in the tertiary treatment of wastewater in many countries including some of the Arab countries (Feldthusen, 2004). This study assessed the suitability of this technique for application in water treatment by monitoring the efficiency of a pilot scale unit in treating the heavily polluted Nile water. Comparison of performance with a traditional unit (pulsator followed by filtration) under same loading conditions divulged the superiority of the introduced system.

MATERIALS AMD METHODS

Sample Analysis

The qualities of the raw and treated water were assessed by monitoring different parameters, namely, turbidity, residual alum concentration and residual chlorine. In addition, due to the prevalence of high algal blooming in the river that severely affected the performance of the pulsator and the subsequent filtration unit in the existing plant itself, it was decided to also monitor the performance of the DynaSand unit in respect to the loading of algae (algae count).

The analyses of the samples were carried out as per the Standard Methods and were performed at the central laboratories of the plant.

Working Principle of Dynamic Sand Filtration

Moving bed sand filter, which is commercially known as DynaSand Filter, is a continuous-backwash, up-flow, deep-bed, granular media filter (Fig. 1). The basic principle of continuous contact filtration is that precipitation and flocculation and flocculation removal take place directly in DynaSand filters. The sand bed works as a flocculation reactor and filter. The result is that the treatment plant space requirement can be reduced by 70-80%, since there is no need for any flocculation, sedimentation or flotation step. Moreover, continuous operation means that peripheral equipment such as backwash water pumps, automatic backwash valves and control system and backwash water storage can be completely eliminated.

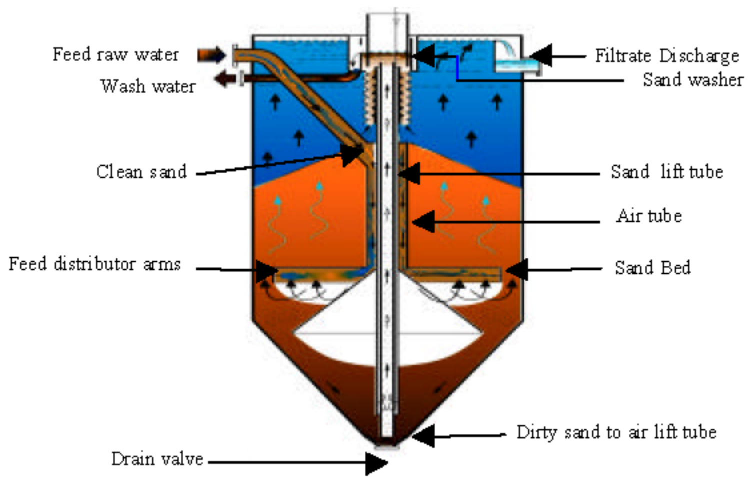

Fig. 1: Typical DynaSand filter

Fig. 2: The DynaSand unit located in Fostat water plant, Cairo, Egypt

The filter media is continuously cleaned by recycling of the sand internally through an airlift pipe and sand washer. The cleansed sand is redistributed on top of the sand bed allowing for continuous, uninterrupted flow of filtrate and reject (backwash) water. Feed is introduced at the bottom of the filter through a series of feed radials and flows upward through the sand bed bottom.

As the influent flows upward, solids are trapped in the sand bed. The filtrate exits over an effluent weir at the top of the filter. Simultaneously, the sand bed, along with the accumulated solids is drawn downward into the airlift pipe which is located in the center of the filter. A small volume of compressed air is introduced at the bottom of the airlift. The air rises, draws the sand into the airlift and scours the sand of trapped particles and excess biomass.

Upon reaching the top of the airlift, the dirty slurry spills over into the central reject compartment. The sand is returned to the sand bed through the washer/separator. As the sand falls through the washer, which consists of several concentric stages, a small amount of filtered water passes upward, washing away the dirt, while allowing the heavier, coarser sand to fall through to the bed. By setting the reject weir at a lower level than the filtrate weir, a steady stream of wash water is assured.

The continuous reject exits near the top of the filter. In this way, the sand bed is continuously cleaned while both a continuous filtrate and reject are produced.

Description of Pilot Plant

The performance of the unit with a capacity of 7 $m^3 h^{-1}$ was compared with that of the existing traditional plant (pulsator followed by filtration) at that site (Fig. 2). The unit was fed with raw water from the rive Nile. The feed water was pre-chlorinated and dosed with alum prior to feeding.

RESULTS

Figure 3-8 shows the results obtained throughout continuous operation of the DynaSand unit. As compared to a high turbidity of 3-14 NTU of the raw Nile water, the turbidity of the treated water from the DynaSand unit was in the range of 0.2-1 NTU. On the other hand, the turbidity of the effluent from the existing plant ranged in between 0.5 and 1.2 NTU.

Against an alum concentration of 1.2 ppm in the raw water, the alum concentration after the DynaSand treatment stood at 0.2 ppm. The corresponding value of residual alum in the effluent from the existing unit was 0.2-1.2 ppm. Conversely, the residual chlorine in the treated water was in the range of 1-2.5 ppm.

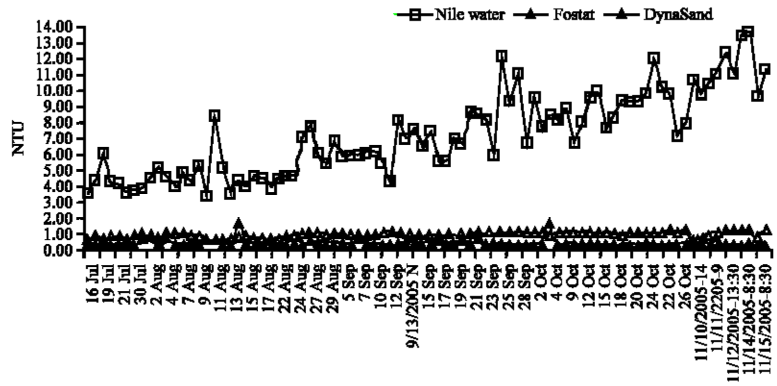

Fig. 3: Turbidity (Nile River-Fosta-DynaSand)

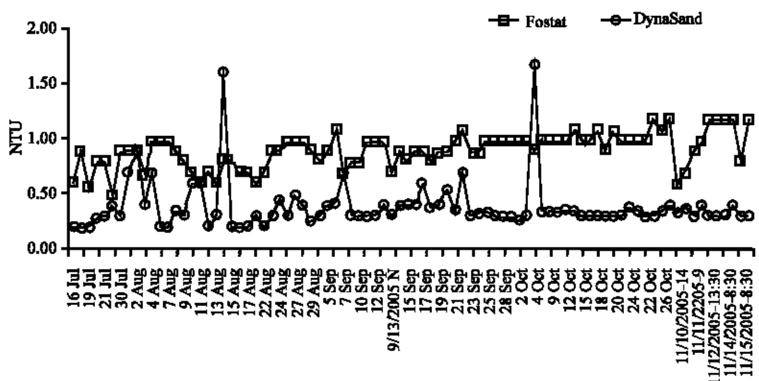

Fig. 4: Turbidity (fostat vs DynaSand)

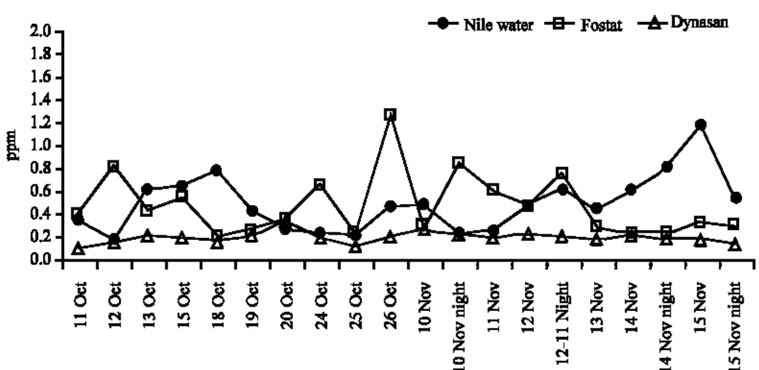

Fig. 5: Residual Alum (Nile-Fostat-DynaSand)

The algae count in the effluent of the DynaSand and the existing unit were around 100 and 150-500, respectively. The effluent from the unit convincingly conformed to the local standards.

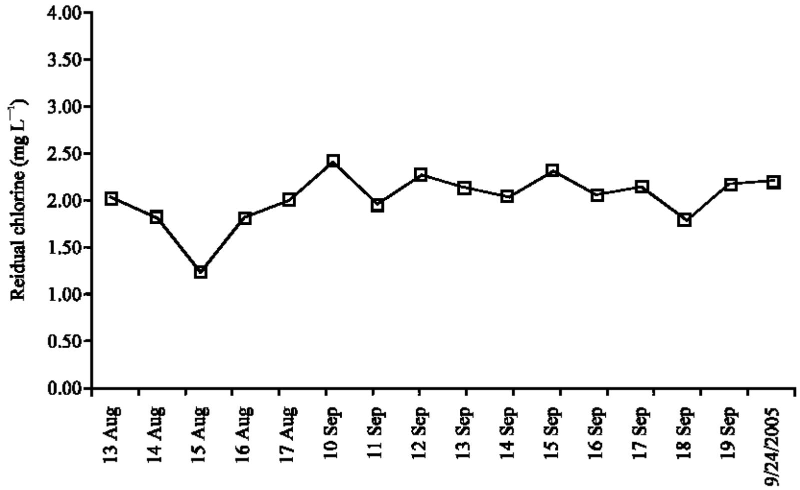

Fig. 6: Residual chlorine for DynaSand

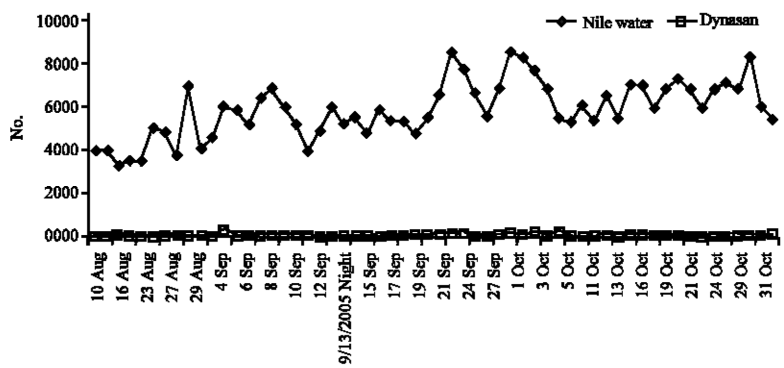

Fig. 7: Algae (Nile vs DynaSand)

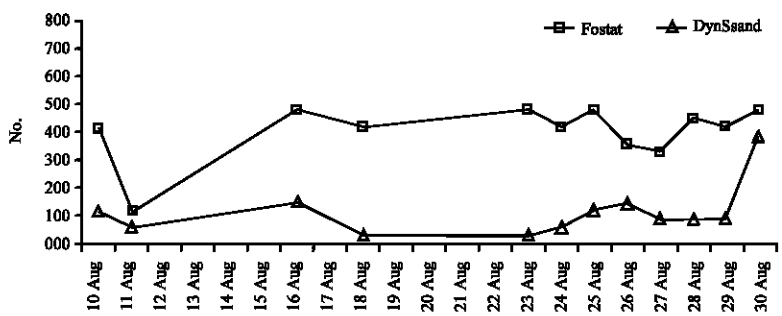

Fig. 8: Algae (Fostat vs DynaSand)

DISCUSSION

DynaSand filtration was successfully applied in wastewater treatment at the beginning (Vach, 2003) and this success led to trials for its application in potable water treatment. Since 1998, several water treatment plants using DynaSand filtration technique have been built around the world, for example, Parkson Corporation plant in USA, Balby plant in England and Water Link in Sweden (Vach, 2003). This study assessed the suitability of this technique for application in water treatment by monitoring the efficiency of a pilot scale unit in treating the heavily polluted Nile water.

In this study, during an observation period of 5 months, the dynamic sand filtration unit exhibited a stable performance in terms of removal of turbidity, algae, residual chlorine and residual alum. The Nile water originally contained alum due to pollution. The raw water was additionally dosed with alum to reach its target concentration as a coagulant. However, for potable use the alum concentration in treated water has to be within certain limit. The unit also maintained, in the treated water, appropriate levels of chemical agents (alum, chlorine) which were added for treatment. The performance of the dynamic sand filtration unit, unlike that of the existing treatment unit, was not influenced by the high algae content (4000-9000 algae count) of the raw water.

It is worth-mentioning here that, the sudden leap and subsequent recovery noticed in the curve of the DynaSand was due to stop/re-start following electricity failure/recovery. The immediate retrieval of performance following recovery of electricity indicates the resilience of the system.

CONCLUSIONS

Based on the monitored results, dynamic sand filtration may be considered as a reliable technique for the treatment of Nile water. Under the same loading, the performance of the newly introduced unit was better than or comparable to that of the existing treatment unit (pulsator followed by filtration) at that site. During an observation period of 5 months, the dynamic sand filtration unit exhibited a stable performance in terms of removal of turbidity and algae and maintenance of appropriate levels of chemical agents added for aiding the treatment process (alum, chlorine). The effluent from the unit convincingly conformed to the local standards.

REFERENCES

El-Gohary, F., 1994a. J. Am. Chamber Commerce Egypt, 10: 2.4-2.5 and 2.9-2.11.

El-Gohary, F., 1994b. Comparative environmental risks in Cairo: Water pollution problems. In: Comparing Environmental Health Risks in Cairo, Egypt, USA. ID and GoE, Vol. 2, May 1994.

Feldthusen, M., 2004. Continuous Sand Filters-Tertiary WWT and other Applications. Paper Presented at the Saudi Arabian Water Environment Association 2004 Workshop.

Janssens, J.G., J. Ceulemans and J. Dirickx, 1986. Experiences with direct-filtration: Plant-scale evaluation and pilot-scale investigations. Water Supply, 4: 347-366.

Vach, L.M., 2003. DynaSand application in water and sewage treatments. Water Federation J., pp: 122-129.

Viessman, Jr. W. and M.J. Hammer, 1993. Water Supply and Pollution Control. 5th Edn., HarperCollins, New York.