TREATMENT SPENT FILTER BACKWASH WATER USING DISSOLVED AIR FLOTATION: In Isfahan Water Treatment Plant

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ABSTRACT

Recovering spent filter backwash water is currently receiving a great deal of attention. EPA published the Filter Backwash-Recycling Rule (FBRR) in 2001. Recycle stream may contain significant concentration of pathogens, such as, cryptosporidium and Giardia. Dissolved Air Flotation (DAF) was investigated as a possible technology alternative to simple or advanced sedimentation technology. In this study with using a pilot of DAF effluent turbidities of <20NTU could be easily obtained, when raw water turbidities were in excess of 800 NTU. Chemical requirements were low with only a single low dose of polyaluminium chloride (PACl) required binding the floc particles to form a solids matrix suitable for flotation. The results showed that the efficiency of continuous flow DAF with using PACl as coagulant for removal of Turbidity, COD, HPC and MPN were 97, 72, 75 and 100 percent, respectively. The statistical analyses indicated that the optimum saturation pressure is 4-5 atm, during recycle rate of 20-25 percent. The removal efficiencies of turbidity and bacteria in coagulation with sedimentation were reported up to 70 and 65 percent, while in this study using DAF with coagulant PACl could remove turbidity, COD and bacterial up to 97,72 and, 72 percent respectively.

Key words: Dissolved Air Flotation, Filter backwash water, Heterotrophic Plate Count, Isfahan water treatment plant, Most Probable Number

1. INTRODUCTION

Filtration is a process that is widely used for removing particulate matter from water. Flotation processes have been used for solid-liquid separations since early 1900s. DAF is still an emerging technology for drinking water treatment in North America and Scandinavian countries (Eades and Scheidler, 2001). The purpose for backwashing the filter bed is to remove deposited floc without wash out the media. Most surface waters contain algae, sediment clay, and other organic or inorganic articulate matter. Filtration improves the clarity of water by removing these particles (Qasim et al., 2000). More importantly, all surface waters contain microorganisms that can cause waterborne illnesses, and filtration is nearly always required in conjunction with chemical disinfection to assure that water is free of these pathogens. In granular filtration, waterborne particles are removed as influent water passes through a submerged granular material, or filter medium. From 5 m^3/s water that received to Isfahan WTP, estimated about 8640 m3/d consumes to backwashing porpoise. The amount of backwash water is quit large. It is estimated that a backwash rate of 36 to 42 $m^3/m^2.h$ will be required for a minimum of 10 minutes (Crittenden et al., 2005). Usually the enteric backwash cycle lasts from 8 to 15 minutes (Eades and Scheidler, 2000). The quantity of wash water depends on the wash water flow rate and the duration of the backwash cycle. Filter backwash contains a large volume of water and a relatively small concentration of solids (50 to 1000 mg/L). It constitutes 1 to 5 percent (average of 2 percent) of the total water processed. The solids are difficult to separate. Filter backwash recovery systems needed to recover water for reprocessing and to concentrate solids (Kawamura, 2000). The solids in filter backwash are similar to those in the sedimentation basin typical backwash contains hydrous oxides of aluminum, iron, manganese, and magnesium, carbonates of calcium and iron spent activated carbon. It may contain the algae, bacteria, protozoan cysts and, ditched slime bacteria that are often supported on filter media (Eades and Scheidler, 2000). This water must be disposed of by some means. One efficient means of disposing of waste backwash water is to return it to the head of the plant. The major concern with backwash return water is return and concentration of protozoan cysts in the system (Qasim et al., 2000). EPA published the filter backwash-recycling rule (FBRR) in 2001. The FBRR applies to all system that use surface water or ground water under the direct influence of surface water, practice conventional of direct filtration, and recycle spent filter backwash, thickener supernatant, or liquid from dewatering processes. Recycle stream may contain significant concentration of pathogens, such as, cryptosporidium and Giardia (Eades and Scheidler, 2000). Conventional flocculation and sedimentation process is not very effective in algae blooms, dissolved iron, taste and odor problem, because these are light and settle slowly. DAF is an effective alternative to sedimentation: application of the DAF process to drinking water treatment began in the united state in 1993. By treating this flow both public health and financial liability can be better managed by the operating utility. DAF was investigated as a possible technology alternative to simple or advanced sedimentation technology. DAF is a system that replaces the sedimentation basin with a process that introduces millions of micro-bubbles into the spent filter backwash water (Kawamura, 2000).

2. METHODS

A continues flow DAF reactor in pilot plant, with total volume 310 liter was used. The pilot plant that used in the survey was consists of three part. This has an equalization tank, air saturation system and coagulation, flocculation & flotation basin with total scale: 180∗35∗62 Cm (L.W.H). The quantity of solids in filter backwash depends on the efficiency of the filter and on the pretreatment provided. Where sedimentation precedes the filter, typical suspended solids concentration escaping the sedimentation basins range from 4 to 10 mg/L. Immediately after backwashing, filter effluent will experience high turbidity (Qasim et al., 2000). In this study for minimization of enters turbidity variety, used tank equalization with a mixer. A rectangular tank configuration is designed for DAF, though circular tanks are mostly to smaller or packaged treatment plants. DAF units are typically designed with overflow rate of 5 to 15 m/h, detention time of 5 to 20 min, and tank water depth 1.5 to 3.7 m (Bagwell et al, 2001). Removal of particles in flotation involves three key step 1-bubble formations, 2-bubble- particle attachment, and 3-flotation bubble-particle agglomerate. A typical DAF tank is designed in such way that flocculated water enters at the bottom of one end, where the saturated recycle injectors are located. Before that the filter backwash water was passed a flash mixer and two-floculator basin. An inclined baffle, 60 degree from the horizontal, is located near the inlet of the tank. The baffle separates the tank into reaction and separation zones. The reaction zone, which is the area up stream of the baffle, is where particles and bubbles mix, leading to the formation of particle-bubble agglomerates. Clarified water is collect at end of the DAF tank (Bagwell et al, 2001). DAF is suitable method for backwash water recovery. A schematic of the pilot plant is given in figure 1.

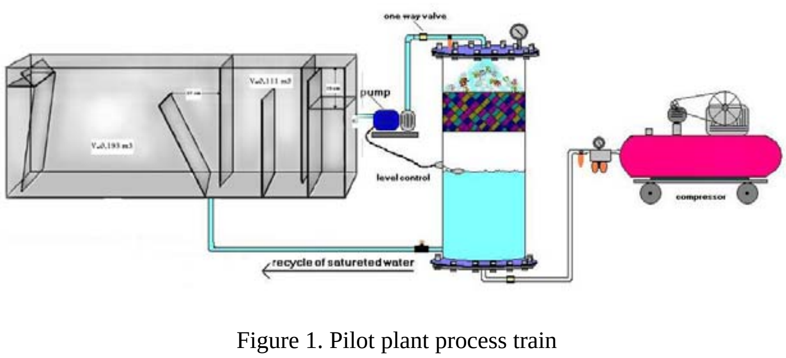

Figure 1. Pilot plant process train

Coagulation in DAF is same as used for sedimentation. However, unlike pretreatment for sedimentation, DAF dose not require large, dense floc. Small floc particles are as well or even better removed by DAF than large floc particles. Chemical dosages are commonly 30 percent less than those required for sedimentation. Generally, flocculent aid polymer is not necessary for DAF, though they can improve process in some cases. DAF in par sedimentation need less flocculation time (5-15min). These shorter times tend to produce "pinpoint" floc similar to that produced for direct filtration that is effectively removed by DAF. Flocculation intensity is also important is producing appropriate floc flotation. Optimum mean velocity gradient (G) is 70 sec^{-1} for flotation (Bagwell et al, 2001).

In a DAF plant, a side stream of treated water is passed through an air saturation system and then to the DAF tank. A 100 liter steel vessel was supported the pressurized water and air mixture. Bubbles are formed in the DAF process as the recycle stream enters the flotation tank and the pressure drops. A saturation tank consists of educators to entrain the air, and recycle pumps with air injection on the suction side. The air saturation system accounts for about on-half the power used in the DAF process, so efficiency is an important consideration in recycle system design (Bagwell et al, 2001). The amount of air released can be approximated based on the solubility of air in water and the system operating condition (Feris and Rubio, 1999). Packed saturators, with typical efficiencies of 90 percent, are efficient than unpacked saturators, which have typical efficiencies of 70 percent. Both mechanical and hydraulic devices are used for removing the float from the surface of a flotation tank (Bagwell et al, 2001). Hydraulic float removing used, because this device was effective. DAF pilot plan installed in Isfahan WTP and for actual condition, feed water used from filter backwashed water. Feed input volume was 6m/h and continues stream used in this pilot. Saturation pressure and recycle rate was varied from 3 to 5 atm and 5% to 30% respectively. For every parameter that was studied, 25 samples were taken from input and out put of pilot plant. Turbidity measurements were made using the HACH 200P. Heterotrophic plate count, MPN and COD results were obtained using standards methods (APHA,1998). COD measurements were archived with HACH COD reactor and pH measurements were archive with *METROHM* 605.

3. RESULTS

The turbidity, COD and bacterial count in filter backwash is high; therefore, the water recovery system should be carefully selected, because backwash has the potential for release of taste and odor casing compounds (Qasim et al., 2000). Given this a pilot plant program, supported by jar testing, was under taken to determine the process capability and the design parameters for these applications. For jar testing, measurements of pH and coagulant dosages were needed. pH characterization studies of 25 grab samples at different times during the study period indicated that backwash water have suitable pH for coagulation associated with PACl coagulant. In acidify synthetic samples with PACl increase in turbidity was obtained. Optimum PACl dosage obtain 10 to 15 mg/L associated input turbidity.

3.1. Turbidity removal by DAF pilot plant

In full scale monitoring clarification process performance always is by turbidity measurement. Figure 2 provides the data for the turbidity removal across the DAF pilot plant for this study. In figure 3 showed the percents turbidity removal. Of note is the stability of the DAF turbidity in association to the changes in raw water turbidity. Average percent turbidity removal was 89% with a peak of 97.8%. Turbidity removal result for different saturation pressure and recycle rate studies presented in figure 4 and 5.

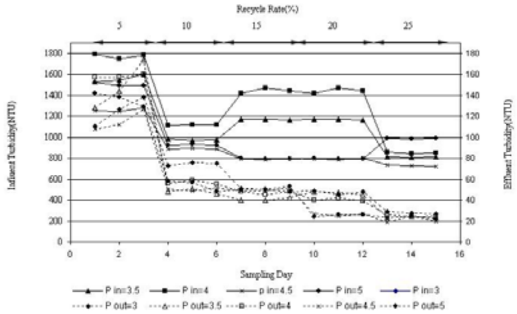

Figure 2. Input and out put turbidity in DAF pilot

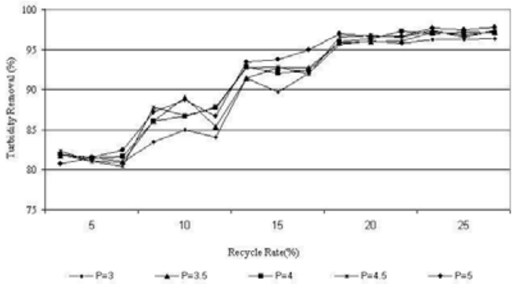

Figure 3. Turbidity removal percent

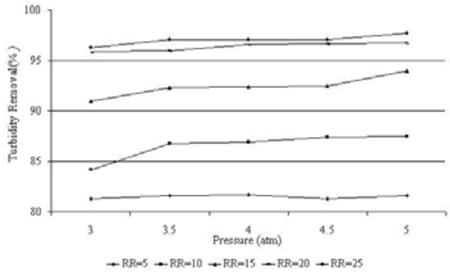

Figure 4. Turbidity removal in different saturation pressure

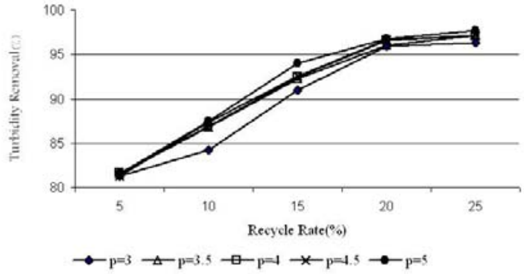

Figure 5. Turbidity removal in different recycle rate

3.2. COD removal in DAF

Figure 6 gives data from these studies shows the variety of percent COD removal. Figure 7 and 8 shows, percent COD removal associated with different recycle rate and saturation pressure respectively. Figures 7 and 8 show that with increase pressure and recycle rate, increase COD removal will obtained.

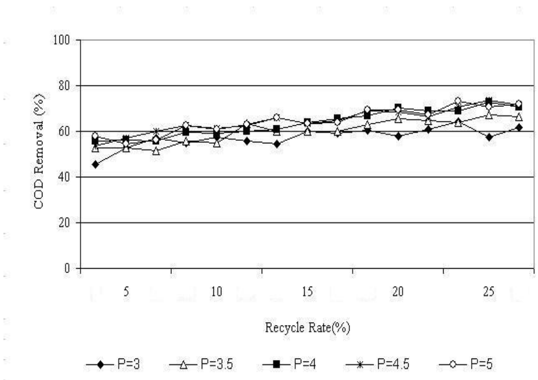

Figure 6. COD removal percent

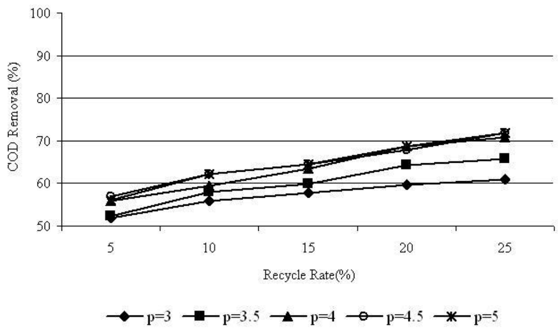

Figure 7. COD removal in different recycle rate

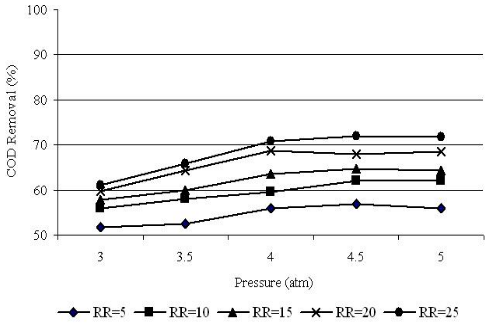

Figure 8. COD removal in different saturation pressure

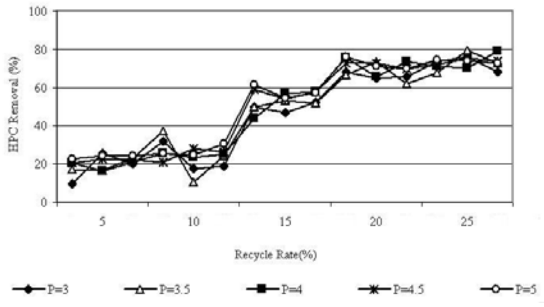

Figure 9. HPC removal percent

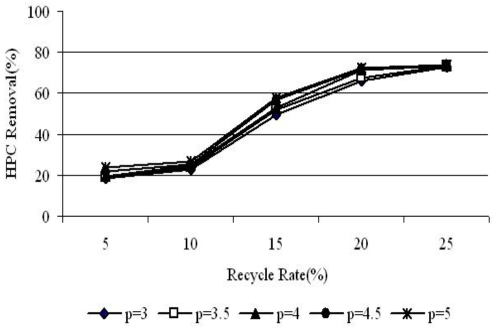

Figure 10. HPC removal in different Recycle rate

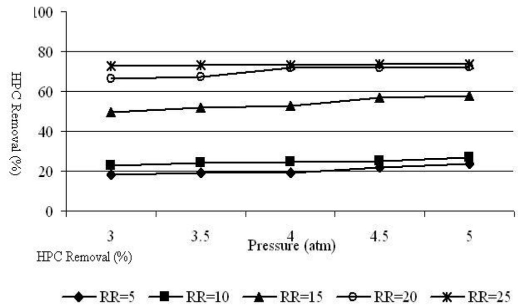

Figure 11. HPC removal in different saturation pressure

3.3. Bacterial removal in DAF

To determine the bacteriological property in this study, MPN and HPC parameter studies. Bacterial density in water sample can be determined by serial dilutions in multiple tubes using the fermentation technique (Kawamura 2000). Statistical estimate concentration of total Coliform bacteria are reported as MPN. The HPC is often used to evaluate the performance of treatment processes and regrowth in effluent distribution systems in reuse applications (Tchobanoglous 2003). Before filtration process, ozonation to purpose disinfection was applied. Ozonation has great ability in microorganism disappear. Before filtration process, ozonation to purpose disinfection was applied. Ozonation has great ability in microorganism disappear. So backwash water has a few bacterial. Figure 9 shows HPC removal in DAF pilot. Figures 10 and 11 are giving information about recycle rate and saturation pressure in HPC removal percent. Because ozonation is used, not many total and fecal cloiform was present in input an output waters. In 99% of samples not find any fecal cloiform in treated backwash water.

4. DISCUSSION

It is concluded that the continuous flow DAF can be an efficient method for turbidity, COD and bacteria removal from filter backwash water in Isfahan WTP. The most effective chemical will depend upon the raw-water quality. Coagulant dose and pH have a strong effect on DAF and should be tested at the pilot scale. Unlike sedimentation the DAF process must produces small and light flocs, which attach to a large number of air bubbles that float to the surface (Qasim et al., 2000). The removal efficiencies of turbidity and bacteria in coagulation with sedimentation were reported up to 70 and 65 percent, while in this study using DAF with coagulant PACl could remove turbidity, COD and bacterial up to 97,72 and, 72 percent respectively. Wash water recovery ponds achieved 80 percent concentration of solids in 24 hours with use of polymers or other coagulant aids (Terence and Ghee, 1991). But DAF in optimum condition can remove more than 97% turbidity. For turbidity, COD and bacterial removal, best result, in 5 atm saturation pressure and 25% recycle rate obtained. Economical condition was in 4atm pressure and 20% recycle rate observed.

5. REFERENCES

APHA, AWWA, WPCF. (1998): *Standard Methods for the Examination of Water and wastewater,* Washington DC, American Public Health Association.

Bagwell, T., Barrett, K., Benjes, S., et al. (2001): *Handbook of Public Water System*. Second ed. John Wiley & Sons Inc

Crittenden, J.C., Trussell, R., Hand, D.W., Howe, K.J., Tchobanoglous, G., (2005): *Water Treatment Principle and Design,* Second ed. John Wiley & Sons Inc

Eades, A., Bates, B.J., Macphee, M.J. (2001): Treatment of Spent Filter Backwash Water using Dissolved Air Flotation, *J. Water Science and Technology.*

Eades, A., Scheidler, S. (2001): *Recovering Spent Filter Backwash Water using Dissolved Air Flotation Technology,* Florida Water Resources.

Feris, L.A., Rubio, J. (1999): *Dissolved Air Flotation (DAF) Performance at Low Saturation pressures, filtration & Separation*, Department de Engeharia de Minas-PPGEM.

Kawamura, S. (2000): *Integrated Design and operation of water treatment Facilities,* 2end ed. John Wiley & Sons Inc.

Qasim, S.R., Motely, E.M., Zhu, G. (2000): *Water Work Engineering Planning & Operation,* Hall PTR.

Terence, J., Ghee., (1991): *Water Supply and Sewerage*, 6th ed. Mc Grow- Hill

USEPA., *Using DWSRF Fund to Comply with the Filter Backwash Recycling Rule.*, Preamable http://www.epa.gov