

## Effect of Dissolved Air Flotation Process on Thickening of Activated Sludge

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### Abstract

**Aims:** Sludge is an inescapable component of all wastewaters that originated from their treatment. dissolved air flotation (DAF) process as an alternative clarifier is used in treatment of drinking water, pretreatment of wastewater, and as a phase separator in sludge activation processes. This study aimed to calibrated the usage of DAF process in a laboratory scale and under various conditions, to achieve the optimum efficiency in recycling the activated sludge.

**Instrument & Methods:** In this experimental study, of Kashan's Shahid Beheshti hospital and immediately transported to the laboratory. The optimal dose of polyaluminum chloride coagulant and pH was determined and then applied in DAF process. Finally turbidity, electrical conductivity (EC) and total solids (TS) parameters were measured and compared with control sample.

**Findings:** The optimal pH and optimal dose of coagulant were 6.5 and 25mg/l, respectively. Also Optimal process efficiency to reduce EC, TS and turbidity parameters were 23.4, 44.5 and 88%, respectively.

**Conclusion:** Dissolved air flotation process removes the turbidity, EC and TS effectively; however, it has minimal impact on EC and TS.

### Keywords

Dissolved Air Flotation [Not in MeSH];

Hospitals [<https://www.ncbi.nlm.nih.gov/mesh/68006761>];

Recycling [<https://www.ncbi.nlm.nih.gov/mesh/68059027>];

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## Introduction

Every year, 330km<sup>3</sup> of municipal wastewater is generated around the world, continuously [1]. Recently, hospital wastewaters have become an associated issue as a water source contaminant that has higher concentrations of pharmaceuticals, mainly antibiotics and analgesics, compared with municipal wastewater [2]. Sludge is an inescapable component of all wastewaters that originated from their treatment [3]. Sludge activation process can remove pharmaceutical about 85% [4]. Intensification of current environmental legislation leads to increase the wastewater treatment sludge volume [5]. 25-60% of wastewater treatment total operating cost is related to the disposal of excess sludge. Therefore, reducing the sludge is considered as a strategy to improve and solves the problems of secondary pollution of sludge [6].

While treatment of wastewater liquid portions takes about several hours, processing and preparation sludge for disposal or beneficial uses with advanced equipment, will take several days or several weeks [7]. Fermentation, denitrification, and anamox can remove the nitrogen and reduce the sludge volume for reusing [8]. In addition, sludge volume decreasing up to 20% was observed [9]. Due to low energy consumption, reducing the volume of sludge by mechanical dewatering process is usual in comparison with thermal drying [5]. Sedimentation, as a final clarifier and sludge thickener, has some limitations; Not operating in sludge bulking occurrence and large retention time resulting in high land use and capital cost. Flotation has also been used for solid/liquid phase separation in water and wastewater treatment and has shorter residence time than sedimentation [10].

Literature has reported effective coagulation and flotation by nano-bubbles [11, 12]. DAF process as an alternative clarifier is used in treatment of drinking water, pretreatment of wastewater, and as a phase separator in sludge activation processes [13, 14]. For decades, a large number of wastewater treatment plants have used DAF to access a high amount of thickened sludge [15]. High efficiency of DAF as a secondary clarifier in sludge activation have been demonstrated [16]. In DAF system, air dissolve in water at an air-pressurized

tank. Saturated water then conducts to flotation region with atmospheric pressure. As a result, thousands of bubbles are generated and move upward. This movement causes particle separation from liquid [17].

Due to the importance of sludge volume, its complications, and sludge thickening high cost allocation, this study aimed to calibrated the usage of Dissolved Air Flotation process in a laboratory scale and under various conditions, to achieve the optimum efficiency in recycling the activated sludge.

## Instrument & Methods

In this experimental study, all tests were performed in the Research Laboratory of Public Health School, Kashan University of Medical Sciences.

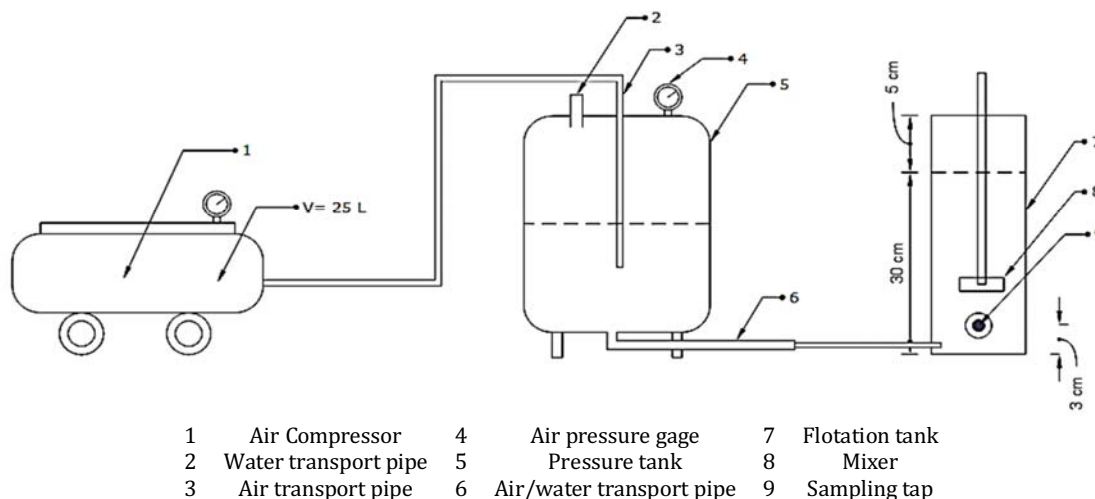
The lab-scale reactor was built based on a sequence batch reactor (SBR) and consists of a flotation tank, a pressure tank (117 liters), and an air compressor with a capacity of 25-liters (Figure 1). The floater tank had a cross sectional area of 10×10cm<sup>2</sup> and a height of 35cm, which occupied by 3 liters of water (30cm). Sampling port placed at a distance of 3cm from the bottom of the tank. Given the DAF laboratory scale based on a SBR system, coagulation, flocculation and flotation steps were done in the flotation vessel, respectively. At first, pH and coagulant dose were optimized via jar test. Poly aluminum chloride (PAC) was used as the coagulant (Falizan; Iran).

The effect of recycling rate on flotation efficiency was carried out at 20, 35 and 50%. Recycling rate (R) was calculated by  $r/v$ , where  $r$  is saturated flow/volume and  $v$  is sludge flow/volume [18]. Considering the flotation tank volume in all experiments, sums of  $r$  and  $v$  amount were calculated 3000ml.

According to the following equation, DAF performance depends on the air to solids ratio (A/S) which affects solid/liquid separation [19].

$$\frac{A}{S} = \frac{1.3 S_a (fP - 1)R}{S_u}$$

Where  $S_a$  is air solubility (18.7 ml/l at 20), R is recycling rate (%),  $f$  is fraction of air dissolved at pressure P (usually 0.5), P is pressure (atm), and  $S_u$  is suspended solids (mg/l). Typical A/S ratio in the wastewater sludge thickening is about 0.005-0.06 [20].



**Figure 1)** A schematic diagram of DAF lab-scale

Daily samples were taken from the wastewater treatment plant of Kashan's Shahid Beheshti hospital and immediately transported to the laboratory. Sludge characteristics, e.g. pH, TS, total suspended solids (TSS), turbidity, and EC were measured at room temperature. The variation of turbidity, EC, and pH were analyzed by Turbidimeter 2100P (HACH; United States), Conductivimeter (Metrohm; United Kingdom), and 262 pH-meter (Tajhizat Sanjesh; Iran), respectively. TS and TSS analyses were done according to APHA [21].

For assessment of DAF efficiency, a specified volume of water was dumped into the pressure tank for 30min under 5 and 7atm. At the same time, certain amount of sludge sample according to the determined recycling rate (20, 35 and 50%) was dumped into the flotation tank. Then, coagulation took place at 180rpm for 1min and flocculation was done at 30rpm for 20min. In the next step, saturated water with an average flow rate of 0.127m<sup>3</sup>/h was entered to the flotation tank (up to 3 liters) and the tank was filled. Finally, samples were taken with an interval time of 2 and 5 minutes from the bottom of flotation tank and TS, turbidity, and EC parameters were measured for comparing with control samples to assess the efficiency of DAF process.

All experiments were done 3 times and the data was entered to SPSS 19 software. Averages were used to report the results.

## Findings

The average pH of activated sludge was 6.4. Therefore, considering to the cost saving, pH

adjustment during the experiments was avoided. The average amount of suspended solids in daily samples was 323mg/l. At the pressure of 7atm and recycling rates of 20, 35 and 50%, A/S ratios were calculated 0.037, 0.065 and 0.097 and at 5atm, were calculated 0.022, 0.039, and 0.056, respectively.

The highest removal efficiency of turbidity was 88% for both 2- and 5min at 7atm by 50% of recycling rate and the lowest was 33% for 2min by 35% of recycling rate. The highest removal efficiency of TS was 44.5% for 5min at 7atm by 50% of recycling rate and the lowest was 8% for 2min at 7atm by 20% of recycling rate. The highest removal efficiency of EC was 23.2% for 5min at 7atm by 50% of recycling rate and the lowest was 10% for 2min at 5atm by 20% of recycling rate (Figure 2).

**Figure 2)** Removal percentage of TS, turbidity, and EC

Parameter	Time (min)	Recycling Rate (%)	Pressure (atm)	
			5	7
Turbidity	2	20	41	54
		35	33	60.5
		50	62.5	88
	5	20	66.5	58
		35	73.5	67
		50	64	88
TS	2	20	8.5	8
		35	21.5	12.6
		50	27	27.3
	5	20	15.5	10.2
		35	22	12.3
		50	24	44.5
EC	2	20	10	13.4
		35	15.5	15.6
		50	17	19.5
	5	20	11	15.3
		35	17	16.6
		50	18	23.2

## Discussion

The aim of this study was to assess the efficiency of DAF process on recycling the activated sludge in wastewater treatment plant of Kashan's Shahid Beheshti Hospital. Optimal efficiencies in removing of EC, TS and turbidity parameters were determined to be 23.3, 44.5, and 88%, respectively. By increasing the amounts of recycling rates, removal efficiency has been increased. The average removal efficiency of TS at recycling rates of 20, 35, and 50% were determined to be 10.5, 17.1, and 30.7%. These amounts at turbidity removal were 54.2, 58.5, and 76.2%. In addition, percentages of EC removal were calculated 12.4, 16.1, and 19.4, respectively. De Nardi *et al.* have demonstrated the decreasing of COD by increasing of recycling rate [22].

Average percentages of EC removal at 2 and 5 minutes determined 15.1 and 17.5. Also, during the specified times, TS removal 17.5 and 21.4% and turbidity removal 56.5 and 69.5% were calculated, respectively. Therefore, it can be concluded that during the time, all parameters of removal efficiencies were increased. This increase was insignificant for EC and TS. In some investigations, increasing of efficiency during the time has been seen [7, 11, 23-25].

Generally, the solubility of air in water increases linearly with increasing pressure, leading to higher efficiency [26]. The results of the removal efficiency of EC, TS and turbidity based on pressure changes (5 and 7 atm), showed not certain relationship. They calculated for EC 14.7, 17.9%, for TS, 19.7, 19.1 and for turbidity 56.7 and 62.9%. Mohd Nordin Adlan *et al.* have reported that the flow rate and pressure are not critical parameters to leachate treatment [27]. However, Qidian Zhang *et al.* have shown that the total amount of suspended solids by increasing the pressure from 0.1 to 0.5MPa, decreased from 25mg/l to 12mg/l [28]. Also, the increasing of 15% of efficiency was observed at another study, with increasing the pressure from 2 to 6 bars [29].

However, in the cases of EC and turbidity, this relationship was direct and it can be deduced that the pressure changes only had a significant impact on the turbidity removal efficiency.

## Conclusion

Dissolved air flotation process removes the turbidity, EC and TS effectively; however, it has minimal impact on EC and TS.

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**Ethical Permissions:** Not needed.

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