Journal of Environmental Science and Engineering A 11 (2022) 195-200
doi:10.17265/2162-5298/2022.06.001

# Comparison between Two Urban Wastewater Primary Treatment Trains

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**Abstract:** This paper evaluated two different wastewater primary treatments of wastewater from the “Universidad Autonoma Metropolitana, Azcapotzalco Campus”, a conventional one integrated for coagulation, flocculation, sedimentation and filtration versus one alternative integrated for in-line coagulation to precondition to rapid filtration. The wastewater was from the Azcapotzalco Campus in Mexico City, and in both cases, we characterized the wastewater, measured: pH, conductivity, temperature, total dissolved solids, dissolved oxygen, ORP (Oxide Reduction Potential), turbidity, and COD (Chemical Oxygen Demand). Conventional treatment was slightly better treatment, but the alternative treatment represents saving in equipment, reactive, energy and time, so it was considered a viable technical and economic wastewater primary treatment.

**Key words:** Wastewater primary treatment, rapid filter performance, static mixer.

## 1. Introduction

The main purpose of this paper was to compare the concentration reduction of dissolved and colloidal solids presented in urban wastewater discharges, between the conventional primary treatment, integrated for the processes of coagulation, flocculation, and the operation of sedimentation and filtration versus an alternative primary treatment, which consisted of in-line coagulation mixing the coagulant with an static mixer eliminating flocculation and sedimentation and changing atmospheric filtration for rapid filtration.

Wastewater from the campus, contains inorganic particulate, organic particulate including viruses, bacteria and protozoan cyst, and very fine colloidal and dissolved organic constituents. Removal of inorganic and colloidal particulates occurred in the primary treatment, and partially the organic particulates are removed in the secondary treatment through oxidation processes, biological or chemical.

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Primary treatment to remove colloidal particulates, conventionally occurred through coagulation, flocculation, where colloids are destabilized and floc formation occurred [1, 2] and after the flocs are sending to sedimentation and filtration. In this work we evaluate the performance of only precoat of in-line filtration [3], eliminating the flocculation and sedimentation operations to reduce the time and cost of the suspended and colloidal particles.

Coagulation is a chemical water treatment complex process to remove solids involving many reactions and mass transfer steps in three separate and sequential steps. Coagulation formation, particle destabilization, and interparticle collisions, that occur during and immediately after introducing small highly charged molecules or electrolyte dispersed in rapid mixing where interparticle collision causes aggregate (floc) formation.

In conventional treatment the physical process of interparticle contact and particle destabilization is enhanced by adsorption of large organic polymers and the formation of particle-polymer-particle bridges or flocculation, where the polymer enhances floc formation initiated with the coagulant destabilization, increasing the floc structure in a slow process and acting as coagulant aid and improving the filter efficiency or acting as a filter aid in a slow process [4].

For coagulation, we used aluminum sulfate or alum [$Al_2(SO_4)_3 \cdot 14H_2O$] which reacts instantaneously with a rapid mixing at 250 rpm during 3 min, and forms aluminum hydrolysis products that cause coagulation, species formed during and after the alum is mixed with the wastewater to be treated.

To flocculation, we used Bentonite clay, that contains aluminum and silica and presents strong colloidal properties, increasing its volume several times when coming into contact by water absorption, creating a large adsorption surface that attracts and adsorbs particles.

Bentonite also is emerging as adsorbent for water treatment since it shows excellent adsorption performance [5], also its negative charge has a high cation exchange capacity and attracts and removes positively inorganic charged ions like magnesium, sodium, and potassium, and it may also attract positively charged toxins [6], with a cost advantage.

Rapid filtration is obtained with the use of coagulant to precondition the water, feeding the coagulant through a static mixer with the use a of a pump to send the water coagulated through a three-stage filtration system, consisted in a first stage of a closed filter with coarse media sand and gravel to remove particles between 100-2,000 μm, in the second stage of a closed filter with anthracite to remove 5 μm particle and in the third stage of a filter with a polyester cartridge to reinforce the filtration of 5 μm particles.

In the experiments, we measured the oxide-reduction potential, temperature, electric conductivity, dissolved oxygen, and the initial and final COD (Chemical Oxygen Demand) and turbidity for its correlation with total suspended solid that governs the amount of particles filtrated and the sludge that generates [7].

## 2. Material and Methods

We made jar test in order to obtain the optimum amount of alum as coagulant for inline filtration, and conventional primary treatment, and Bentonite as flocculent for conventional treatment.

For coagulation we used a sample of 1 L of wastewater from the Azcapotzalco Campus, noticing that the work was realized during the pandemic of COVID-19, where there was a low attendance of students and personnel and the turbidity had small values of 86 NTU.

According to Crittenden et al [7], with turbidity less than 100 NTU, the suspended solids (in mg/L) have been shown to be approximately equal to the turbidity, assuming that for the pandemic the organic content was insignificant.

Also, a correlation has been reported in the case of domestic wastewater between turbidity and total suspended solids in the range of 35-465 mg SST/L and 12-263 NTU [8].

We added the alum $Al_2(SO_4)_3 \cdot 14H_2O$ at 7% with a rapid mixing of 250 rpm during 3 min to generate the turbulence and get in contact the reactive with the wastewater since the reaction is carried on in 0.3 seconds

Once the wastewater was coagulated, we added 1 g of Bentonite in a slow mixing of 25 rpm during 25 min to promote the flocculation and increase the weight and sedimentation/filtration of the particles. The optimum amount to coagulation was 100 mg/L of alum as shown in Fig. 1.

## 2. Alum Ml/l

### 2.1 Treatment Trains

Fig. 2 shows the conventional treatment, where after sedimentation, the filtration system consists of first a multi-stage filter with grave and silica sand, second a filter of anthracite and third a cartridge of polyester, system that also was used for rapid filtration in the alternative treatment train.

Fig. 3 shows the sedimentation tank used to the conventional treatment.

Fig. 4 shows in-line coagulation and rapid filtration train using the static mixer as shows in Fig. 5.

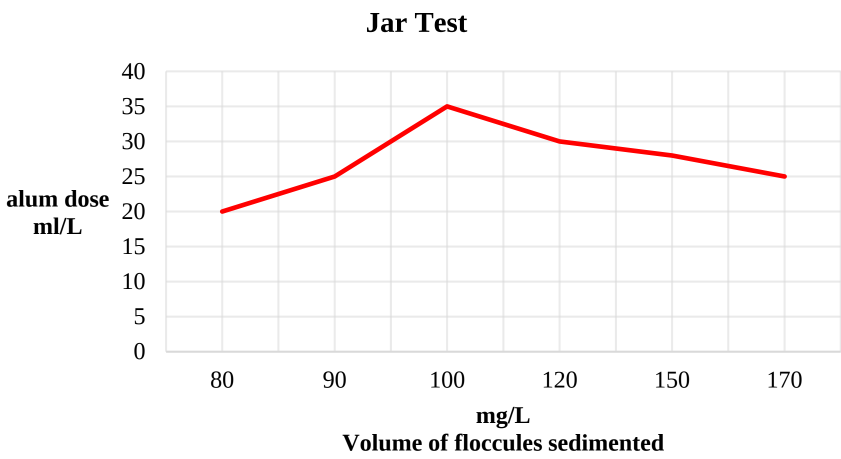


**Fig. 1 Optimum amount of alum as coagulant.**

**Fig. 2 Wastewater conventional treatment train.**

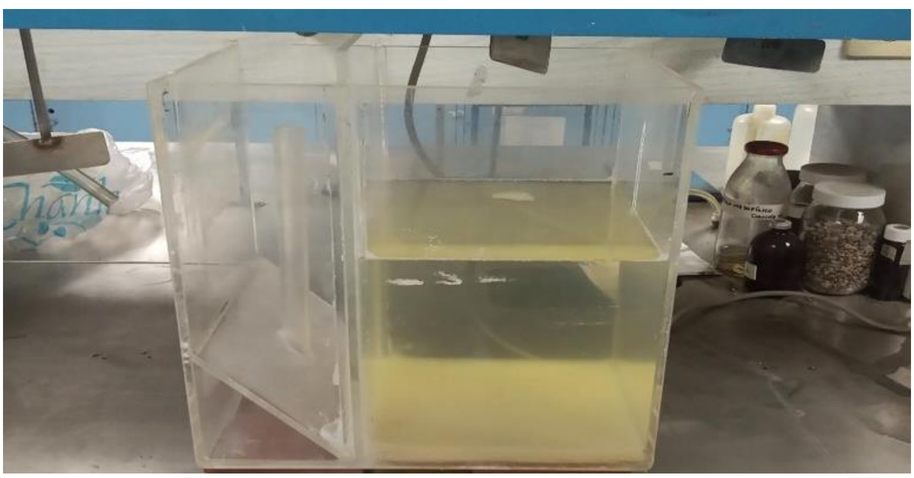

**Fig. 3 Conventional treatment sedimentation tank.**

**Fig. 4 In-line coagulation and rapid filtration train.**

**Fig. 5 Static mixer.**

The parameters were measured with a direct reading multi-parameter monitor YSI model 556 MPS. The COD was digested in a HACH Reactor and was analyzed with a HANNA Photometer multi-parameter model HI 83399, and turbidity with a HANNA analyzer.

## 3. Results and Discussion

In Table 1, we analyzed in three samples each parameter to compare the treatment efficiency.

Table 2 presents the comparative performance between both treatments, presenting average as well as the efficiency obtained experimentally.

According the results, we observed that electrical conductivity decreases in both treatments, but conventional was better, reaching an efficiency of 48% versus 40%, and is an indicative of dissolved salts ions.

Regarding total dissolved solids, conventional treatment has better results, since coagulation and flocculation are present. Also, the mixture reached with rapid and slow rate agitation is better than the mixture from the static mixer.

**Table 1 Parameters with and witouat treatments.**

| Sample | Wastewater | Conventional treatment | | | In-line coagulation and rapid filtration | | |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 1 | 2 | 3 |
| Conductivity, σ (μS/cm) | 1,863 | 1,075 | 953 | 874 | 869 | 1,093 | 1,361 |
| Total Dissolved solids, TDS (mg/L) | 1.410 | 0.787 | 0.747 | 0.694 | 0.644 | 0.843 | 1.187 |
| Dissolved Oxygen, DO (mg/L) | 2.44 | 7.05 | 3.12 | 3.94 | 5.71 | 4.98 | 5.57 |
| Oxide Reduction Potential, ORP (V) | -114 | -55 | -10 | -10 | -32 | -11 | -17 |
| pH | 8.46 | 7.20 | 6.65 | 6.51 | 6.98 | 6.70 | 6.60 |
| Temperature (℃) | 24.26 | 23.16 | 23.16 | 23.16 | 23.33 | 23.33 | 23.33 |
| Turbidity (NTU) | 65.2 | 22.21 | 22.8 | 22.47 | 23.46 | 23.8 | 23.42 |

**Table 2 Efficiency comparison between treatments.**

| Parameter | Wastewater | Conventional treatment and efficiency | In-line coagulation and rapid filtration and efficiency |
|---|---|---|---|
| σ (μS/cm) | 1,863 | 967.3 (48%) | 1,107.6 (40.6%) |
| TDS (g/L) | 1.410 | 0.742 (47.4 %) | 0.891 (36.8%) |
| DO (mg/L) | 2.44 | 4.70 | 5.42 |
| ORP (V) | -114 | -25 (78.1%) | -20 (82.4%) |
| Turbidity (NTU) | 62.5 | 22.49 (64%) | 23.56 (62.3%) |

**Table 3 COD values, and efficiency.**

| Sample | COD Sample 1 | COD Sample 2 | COD Sample 3 | Average values | Efficiency (%) |
|---|---|---|---|---|---|
| Wastewater | 64 mg/L | 66 mg/L | 65 mg/L | 65mg/L | - |
| Water with conventional treatment | 29 mg/L | 37 mg/L | 49 mg/L | 38.3 mg/L | 42 |
| Water with in-line coagulation and rapid filtration treatment | 35 mg/L | 41 mg/L | 46 mg/L | 40.6 mg/L | 38.5 |

We observed that in-line coagulation has more dissolved oxygen, because the turbulence reached in the static mixer remains in the final value, since it is evaluated almost immediately as difference in conventional treatment that is evaluated after flocculation and sedimentation where dissolved oxygen partially disappeared.

ORP, indicates the nature of the water as oxidant or reducer, showing that alternative treatments obtain better results, since TDS are filtered as coagula's and not are present as the supernatant of sediment water. Therefore the organic content is better removed.

We observed that pH and temperature are almost similar in both treatments, without any significance

Since Chemical Oxygen Demand (COD), has been regulated in March 2022 in a New Mexican code of discharged wastewater to national body water [9], we analyzed it, by triplication in each treatment, as shown in Table 3.

Conventional treatment shows better COD reduction, however it is not significant and also is expected to control this parameter in a secondary treatment.

It is important to mention that COD value is less than the regulated value of 150 mg/L, since in the pandemic period there were minor discharges, and is an atypical value.

## 4. Conclusion

Differences between both treatments are not significant and there is an economical advantage to use the in-line coagulation and rapid filtration, since we can eliminate tanks, mechanical mixers and the flocculent material, as well as, the sedimentation operation, reducing the energy consumption, and the global process is faster.

According to the results we can improve the performance of in-line coagulation if we improve the static mixer efficiency.

We can conclude that in-line coagulation and rapid filtration of coagula's is a cost-effective treatment that can reduce total cost of wastewater primary treatment.

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