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RESEARCH ARTICLE

EFFECT OF BLENDING PROCESS ON RETENTION TIME FOR SLUDGE THICKENING

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ABSTRACT

The objective of this paper is to study the effect of blending process as a method for increasing the efficiency of the gravity thickener on its retention time. The problem is that in Egypt in many wastewater treatment plants, the gravity thickener efficiency is lower than expected, the solids outlet is lower than expected especially when the primary and secondary sludge mixed. In this paper, we study the effect of using dilution water (effluent water from Al Gabal Al Asfar wastewater treatment plant) on the retention time of the gravity thickener. The results explained that it is not suitable to increase the retention time in the gravity thickener when mixing the primary and secondary sludge and when adding the dilution water.

INTRODUCTION

Processing and disposal of sludges from wastewater treatment plants are recieving increasing national attention for several reasons :

- Sludge handling may represent as much as 30-40% of the capital cost of the treatment plant and about 50% of the operating costs. However, most operators of the plants would probably agree that sludge disposal represents 90% of their headaches. This is particularily true for treatment plants located at densely populated urban areas.
- Adoption of the secondary treatment as a national standard will greatly increase the quanitity of biological sludges. The latter are particularily difficult when traditional chemical conditioning is employed.
- Many regulatory agencies are expressing increased concern over the potential for pathogen transmission when sludge is used and run as a fertilizer or soil conditioner.
- In conventional analysis of treatment trains of processing & disposal of sludge, the usual attempt is to optimize one or more of several variables. Factors normally considered for optimization are:
  - Costs and economic impact;
  - Stabilization of organics;
  - Biodegradability;
  - Energy production;
  - Dewaterability.
- Others include; odor control; public health factors; treatment of liquid sidestreams; system flexibilty and reliability; and ease of operation.

Thickening is the process by which biosolids are condensed to produce a concentrated solids product and a relatively solids-free supernatant. Thickening wastewater solids reduces the volume of residuals, improves operation, and reduces costs for subsequent dewatering, processing, transfer, end use, or disposal. For example, thickening liquid-solids (Slurry) from 3 to 6 percent will reduce the volume by 50 percent. The purpose of thickening is to produce a concentrated solids product and a relatively solids – free supernatant but in Egypt, the problem is that the thickener efficiency is lower than the expected efficiency (solid outlet is very low).

Study Objective

The main target of this research is to investigate the effect of water addition with the obtained ratio from lab experiments (El Nadi *et al*., 2014) on the retention time of the gravity thickener and the solids thickening efficiency in continuous flow.

Literature Review

Thickening of sludge is a process to increase its solids concentration and to decrease its volume by removing some of the free water. The resulting material is still fluid. Thickening employed prior to subsequent sludge-processing steps, such as digestion and dewatering, to reduce the volumetric loading and increase the efficiency of subsequent processes (Gabb *et al*., 1998).

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The most commonly used thickening processes are gravity thickening, dissolved air floatation, gravity belt thickening, and rotary drum thickening. Selection of a particular thickening process sometimes depends on the size of the wastewater treatment plant and the downstream train chosen (U.S., 1979).

The main design variables of any thickening process are:

- Solids concentration and flow rate of the feed stream.
- Chemical demand and cost if chemicals are used for conditioning.
- Suspended and dissolved solids concentrations and flow rate of the clarified stream.
- Solids concentration and flow rate of the thickened sludge.

Gravity thickening is the simplest and most commonly used method for sludge thickening in wastewater treatment plants. Circular concrete tanks are the most common configuration for gravity thickeners (Izrail *et al*., 2006). In a continuously operated thickener, there are different zones of concentration. The topmost zone is free of solids and comprises the liquid that eventually escapes over the weirs. The next zone called the feed zone although this zone does not necessarily have the same concentration of feed solids. This zone characterized by a uniform solids concentration. Below the feed zone is the compaction zone a zone of increasing solids concentration (from feed zone concentration to underflow concentration) (U.S., 2003).

To maintain consistent feed to the sludge thickening tanks, primary and waste activated sludge from primary sedimentation basins and from secondary clarifiers respectively, must be blended thoroughly with some amount of dilution water in the sludge-blending tank before entering the sludge thickening tanks. The designed dimensions of a single circular blending tank is based on the value of the total combined sludge plus the dilution water for the combined mass storage and blending period for 2 hours under peak mass loading. The volume of mass entering the blending tank is equal to volume of the combined sludge and the dilution water multiplied by 2-hour blending period. The depth of the circular blending tank is 3m plus 0.6m free board. Based on the volume and the depth the diameter of the blending tank can be determined (Andrew McIntosh, 2009).

Supernatant from gravity thickeners does not have solids concentrations as low as produced by a DAF. Because Secondary sludge are not as well suited for gravity thickeners as primary sludge due to the large quantities of bound water that makes the sludge less dense than primary sludge solids (Amat Sairin and Demun, 1997). Bound Water is water contained within the cell mass of sludge or strongly held on the surface of colloidal particles, which is one of the causes of bulking sludge in the activated sludge process. Mixing of Secondary sludge with Primary sludge and water breaks this bond making the settling of the sludge solids easier and increase the efficiency of the Gravity Thickener (Izrail *et al*., 2006).

According to lab experiments, When using dilution water prior to gravity thickening the dilution water ratio should not exceed 35%, As the efficiency of the gravity thickener decreases after this ratio. In addition, lab experiments showed the increase in biological activities with the increase in the water ratio**.** (El Nadi *et al*., 2014)

MATERIALS AND METHODS

The aim of this study is to investigate the effect of the blending process on the sludge thickening retention time to set up the optimum design parameters for the blending process. The Experimental work plan of the study includes pilot experiments continuous flow type. Sludge samples taken from Al Jabal Al Asfar WWTP. Lab samples from raw sludge (primary and secondary) before the blending process and from the supernatant after the experiment.

The operation program is as follows:

- After the optimum water ratio obtained from previous lab experiments (El Nadi *et al*., 2014) the feeding tank dose the sludge with the dilution water to the three gravity thickeners.
- The sludge flows continuously to the three tanks each with different retention time.
- According to the WWTP the amount of primary sludge produced daily is 15000m^3/day and the excess sludge produced is equal to 42000 m^3/day**.**
- The mixing ratio is 3:7 (primary: excess).
- Water added to the mixed sludge with 35% ratio **(**El Nadi *et al*., 2014).
- Samples are from the supernatant of each gravity thickener after its retention time.
- The return excess sludge from the thickener feed pipe ensure continuous mixing and blending in the feed tank.

Figure 1. Pilot installed in the field

RESULTS AND DISCUSSION

This study was going on a pilot scale running on continuous scale, this phase is divided into 4 runs in each run samples were taken from the supernatant after different retention time and solids analysis were performed to discuss the effect of water addition on the mixed sludge. Knowing that the sludge used in the four runs had almost the same characteristics.

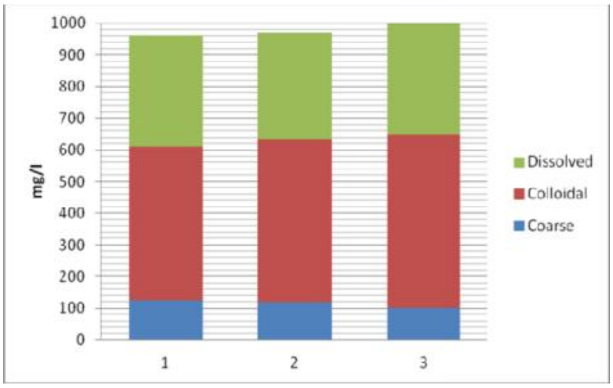

Figure 1. Coarse, Dissolved, Colloidal solids versus water ratio in run I

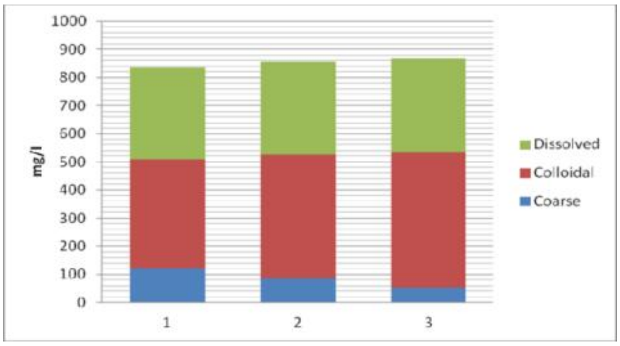

Figure 2. Coarse, Dissolved, Colloidal solids versus water ratio in run II

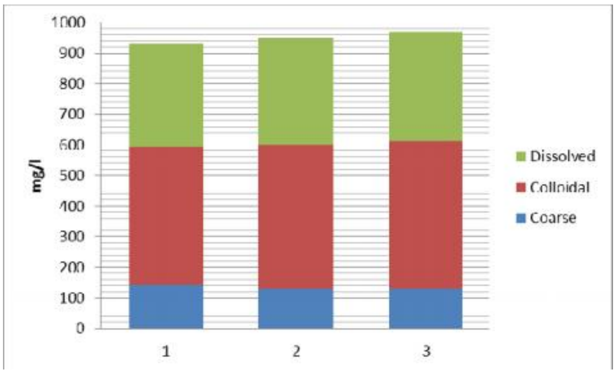

Figure 3. Coarse, Dissolved, Colloidal solids versus water ratio in run III

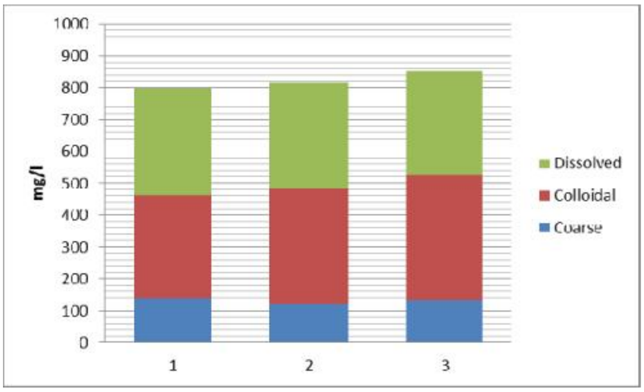

Figure 4. Coarse, Dissolved, Colloidal solids versus water ratio in run IV

Table 1. Run I Classification of solids

Retention time (hours)	16	20	24
Supernatant TS(mg/l)	960	970	997
Supernatant Solids%	36	36	37
Coarse Solids%	13	12	10
Colloidal Solids%	51	53	55
Dissolved Solids%	36	35	35
Volatile Solids%	69	74	75

Table 2. Run II Classification of solids

Retention time (hours)	16	20	24
Supernatant TS(mg/l)	834	855	866
Supernatant Solids%	33	34	34
Coarse Solids%	14	10	6
Colloidal Solids%	47	52	56
Dissolved Solids%	39	38	38
Volatile Solids%	71	73	76

Table 3. Run III Classification of solids

Retention time (hours)	10	12	16
Supernatant TS(mg/l)	932	949	969
Supernatant Solids%	34	35	36
Coarse Solids%	16	13	13
Colloidal Solids%	48	50	51
Dissolved Solids%	36	37	36
Volatile Solids%	64	67	69

Table 4. Run IV Classification of solids

Retention time (hours)	10	12	16
Supernatant TS(mg/l)	798	817	854
Supernatant Solids%	31	32	33
Coarse Solids%	17	15	14
Colloidal Solids%	41	44	47
Dissolved Solids%	42	41	39
Volatile Solids%	62	66	68

The results show that with the increase in retention time the percentage of settled solids decreases by 3% from 16hours to 24 hours, also the TSS in the supernatant increases. However, the problem is that the solids composition in the supernatant shows the decrease in the coarse solids as they are left to settle for 24 hours, but the colloidal and volatile solids increases by the increase in the retention time showing the increase in bacterial activity. In addition, the existence of coarse fraction after 24 hours shows the existence of sludge washout in the supernatant. The results show that with the retention time increase, the non-settable solids in the supernatant increase. The results show that there are still better solid characteristics in the supernatant under shorter retention times as the total solids increase with the increase in retention time also the colloidal and volatile solids increase as significance for the increase of the biological activity.

Conclusion

From the results of phase I the following conclusions could be illustrated:

- The percentage of unsettled solids increase as the retention time increase, the difference between the settled solids in 10 hours and 24 hours was about 4% for the runs due to the increase in biological actions with increase in retention time.

- The percentage of the coarse solids decrease as the retention time increase , the difference between the settled solids in 10 hours and 24 hours was about 5% while the colloidal solids increased by 11% and the dissolved solids were almost constant.
- The TSS in the supernatant increase with the increase in retention time, the TSS at 24 hours increased by about 10% than the TSS at 10 hours.

Recommendations

The study produced the following recommendations:

- It is recommended not to increase retention time if dilution water is used and if the primary and secondary sludge are mixed.
- It is recommended to study the effect of changing the mixing ratio between primary and secondary sludge on the retention time of the thickener

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