Determination of parameters and dosage polymer to compose of the pilot-scale tests of a flocculation-dissolved air flotation system (FDAF)

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Highlights:

- Application of surface modifier polymer on the treatment of sludge generated at a eutrophicated water resource.
- Dimensioning of a pilot-scale tests of a tray flocculation-dissolved air flotation system.
- Possibility of beneficial reuse of sludge due to increase of its solids content.Keywords: flocculation-dissolved air flotation | sludge treatment | Polydadmac polymer | eutrophicated resource | algae

INTRODUCTION

Presidente Castelo Branco Drinking Water Treatment Plant (Tapacurá DWTP), located in the Metropolitan Region of Pernambuco, is one of 73 DWTP that use full cycle process among a total of 248 DWTP, supplies 25% of the population and has capacity of 4.0 m3/s (COMPESA, 2021). The raw water captured from the reservoir is eutrophicated and has been presenting massive blooms of microalgae cyanobacteria. The water quality is seriously compromised, and the algae in the waste generated after the raw water treatment impairs the sludge consolidation and dewatering. Consequently, the treatment is inefficient and the sludge's solids content remains low, which reduces its beneficial reuse potential. Aiming to improve the sludge treatment process, a pilot-scale DWTP was designed using a flocculation-dissolved air flotation (FDAF) system (FREIRE, 2023). The treatment unit is composed of tray flocculators followed by dissolved air flotation (DAF). This paper presents the determination of specific resistance to filtration (SRF), polymer dosage, gradients and superficial application rate (SAR), and solids content of consolidated sludge. The entire study also comprises the sludge characterization; assessment of project parameters considering the most efficient in reducing sludge quality variables; implementation of a pilot-scale DWTP device; and carrying out small-scale tests to verify if the clarified water is according to CONAMA 430/2011 and assess the reuse or disposal possibilities for the sludge, which will be presented in a further paper.

METHODOLOGY

Determination of SRF of sludge was based on filtration time using a vacuum pump and a filtration system (Figure 1), according to APHA (2017) and adapted by Scalize and Di Bernardo (1999), and calculated by SRF=(2.b.P.A2)/µ.C [cm/g], where, b: coefficient [s/cm6], P: pressure [N/m2], A: filtrate area [cm2], µ: filtrated viscosity [g/cm.s]; C: mass of total suspended solids (TSS) in raw water per filtrated volume unit [g/cm3]. The performance of three types of polymers (an anionic, a non-anionic, and a cationic polymer – polyDADMAC) was assessed. Treatability tests were performed using a Flotatest device (capacity of 2L) to determine the best load, molecular weight, and dosage of PolyDADMAC. A polymer solution concentration of 2% was used in the dosages of 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 mg pol/g TSS. The saturation pressure of 0.5, 0.55, and 0.6 MPa, and recirculation rate (R) of 30% and 40% were tested. Gradients and SAR were determined using a bench flotation device with six calibrated jars (Figure 2), saturation serpentine towers (Figure 3,4), air filters, etc. SAR determination used the best result from Flotatest, applying velocities of 8, 10, 15, 19, and 26.6 cm/min. The duration of consolidation tests by dissolved air flotation (DAF) was 20 min. Gradients were tested for velocities varying from 50 s-1 to 100 s-1 at 27°C.

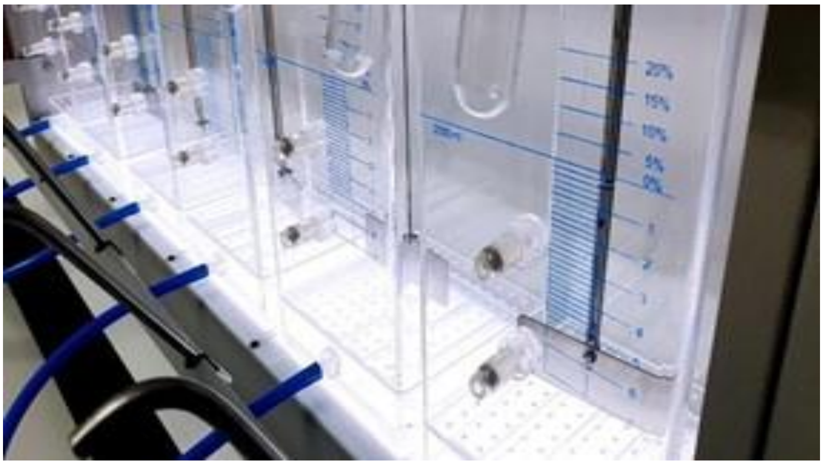

Figure 2 – Calibrated jars.

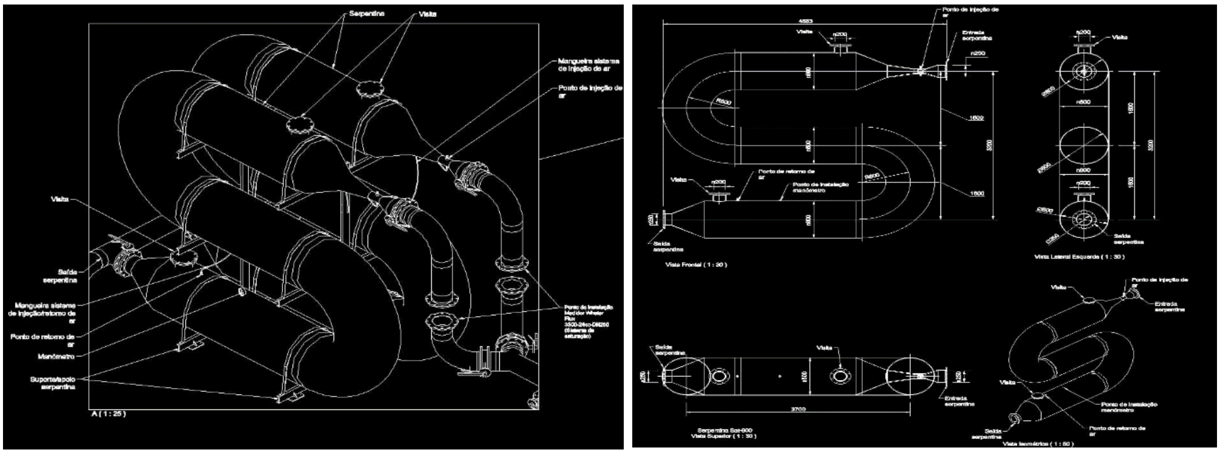

Figure 3 – cutting of the saturated serpentine towers.

RESULTS AND CONCLUSIONS

The sludge generated at the Tapacurá WTP presented TSS of 540 mg/L and SRF of 8.9x1012 m/kg (difficult-to-dewater sludge) for samples without polymer application. The results of the SRF tests (Table 1) indicated that the cationic polymer presented better performance for dosages higher than 2 mg pol./g TSS (SRF of 0.97 x1012 m/kg: easy-to-dewater sludge). The anionic polymer did not reach the recommended SRF of 1x1012 m/kg and the non-anionic polymer reached the recommended only at a dosage of 3.0 mg pol./g TSS. The treatability tests indicated that the best performance obtained was at 5.5 atm of pressure, gradient of 100 s-1, soil circulation rate of 40% and polymer dosage of 3 mg pol. /g TSS, which reduced the initial sludge parameters such as color (930 uC), turbidity (211 uT) and TSS (720 mg/L), respectively, by 98.5%, 97.2% and 98.3%. In addition, the Flotatest results indicated that the rise velocity of 19 cm/min, SAR of 276.6 m3/m2.day, and were the most efficient during the tests. In conclusion, the application of the cationic polymer (Polydadmac; high charge and low molecular weight) at 2 mg in./g TSS was essential for an efficient flocculation-flotation process. The use of Polydadmac as a chemical in the FAD obtains excellent results due to the modification of the bubble surface, in which positive sites are created on the surface, increasing the adhesion efficiency, due to bridges formed between the bubble and the sludge surface (LIU; WANG; WANG, 2021). It improved the dehydration and consolidation of the sludge generated from a eutrophic water resource and reduced the recirculation rate to 40%, which is lower than expected according to the literature. In addition, the serpentine tower positively influenced the quality process during the flotation process. In the cylindrical saturation towers (more common) there is a gradual increase in the agglutination rate of air microbubbles inside the contact zone of the flotation tank (KUMAR et al., 2019). This agglutination is responsible for the decrease in the performance of the FAD during the treatment process (CHAVES, 2015). In the saturation system with cylindrical vessels, there are media (filling support medium) up to a certain height, while in the serpentine the support medium (filling) is along the entire length, providing greater agitation, since its cross-section to the flow is smaller for the same flow range (PARK et al., 2012). The greater the agitation, the lower the possibility of agglutination and formation of air pockets, which are detrimental to saturation (HAN; KIM; KIM, 2015).

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