ABUNDANCE AND SIZE OF ACTIVATED SLUDGE FLOCS IN RELATION TO DYNAMICS OF SOME CHEMICAL PARAMETERS AT WASTEWATER TREATMENT PLANT CONSTANȚA SUD (ROMANIA)

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The aim of this paper is to analyze the relationship between some chemical parameters and sludge volume index during several bulking episodes at a wastewater plant treating both domestic and industrial wastes. More specific, the relation between size of activated sludge flocs, chemical oxygen demand and input of amonium, nitrates and phosphorous is studied. Our observations indicated two distinct situations. First, increased phosphorous input enhanced the production of flocs with large size and correlated with increased values of sludge volume index. The situation was different regarding the input of nitrates when a negative correlation was observed suggesting an unfavourable effect due probably to toxic intermediates released as result of denitrification.

Key words: Activated sludge; Wastewater; Bacteria; Chemical parameters.

INTRODUCTION

Bulking of activated sludge is one of the most common operational problem, affecting the optimal funtioning of the wastewater treatment plants[1,2]. During bulking episodes, activated sludge does not settle well in the final clarifier resulting in a turbid effluent wit high solids content[3–5]. Activated sludge technology rely on the ability of microorganisms to form flocs[6–8]. Floc formation is due to the production by cells of extracellular polymers often polysccharidic that retain together in common mass cells, organic and inorganic particles. Floc size is an important parameter influencing the separation of sludge and effluent in the final clarifier[9]. The increase of sludge volume index (SVI) over 100 mg L^{-1} is occuring commonly during the bulking of sludge[10,11] due to excessive growth of some bacterial species[12,13]. During the bulking upset flocs of sludge have a particular morphology connected commonly with the increase of surface/volume ratio and increased SVI value. Following these ideas, the paper analyzes the dynamics of abundance and size of flocs in relation to the input of nitrate, ammonium phosphorous as well the significance of these processes during bulking episodes at Wastewater Treatment Plant Constanța Sud.

MATERIALS AND METHODS

The study has been carried out during October 2006–January 2007 by weekly analysis of sludge and water sampled from the two aeration basins ((F1, F2). Samples were taken from three points of the tanks (F1, F2): a) wastewater before entering the tank; b) activated sludge from the tank; c) water samples downstream the secondary clarifier. ASRO standard methods have been used to determine the concentration of COD[14], $N\text{-}NO_3$[15], $P\text{-}PO_4$[16], and $N\text{-}NH_4$[17]. Abundance of flocs was estimated by direct microscopic count and their size was measured using a high resolution camera (Euromex) connected to a Novex microscope.

RESULTS AND DISCUSSIONS

Temperature of wastewater presented slight variability, ranging from 12°C to 19°C and pH value showed only minor fluctuations around the neutrla value (7.0-7.6). Phosphorous content of wastewater entering the plant was relatively high, ranging on average between 4.12 mg L^{-1} (F2) and 2.03 mg L^{1} (F1) (Fig. 1b). Phosphorous content was also high in the effluent leaving the plant, about 2-3 mg L^{-1}, suggesting that a considerable proportion is due to the activity of microorganisms in the aeration tanks which can release a significant amount of PO_4 during the organic wastes breakdown. Concentration of N-NH_4 proved large fluctuations as input and output as well. The maximum level of N-NH_4, about 26.52 mg L^{-1}, was recorded during October (Fig. 1c). During the same month it was recorded the highest decrease of N-NH_4 in the aeration tank, with a mean difference of about 23 mg L^{-1} between input and output. Only one analysis revealed a higher amount of N-NH_4 in the treated effluent during October. Lower levels of N-NH_4 have been recorded during January both as input and output (Fig. 1c). Concentration of nitrate (Fig. 1a) was generally higher in the effluent in comparison with the inffluent. This fact can be seen as a result of intense organics degradation and mineralization through nitrification. On the other hand, our data suggest that microbial denitrification was low. Maximum input of nitrate was recorded during January (F1) while maximum output was observed during the same month in the effluent leaving basin F2 (Fig. 1a). COD value was also characterized by significant fluctuations both as input and output (Fig. 1d). The maximum value of COD was recorded in wastewater entering the plant during December and was approximately 156-161 mg L^{-1}. During the same period it was detected the most significant decrease in COD in the effluent leaving the tank F1 where its value was only 28 mg L^{-1} (Fig. 1d). Abundance of sludge flocs. Most data consider that size of flocs could affect the settling characteristics of the activated sludge. In general, the sludge settles well and release high quality effluents when it contains predominantly flocs with a diameter ranging between 50-100 µm. During our observations size class of flocs was highly variable.

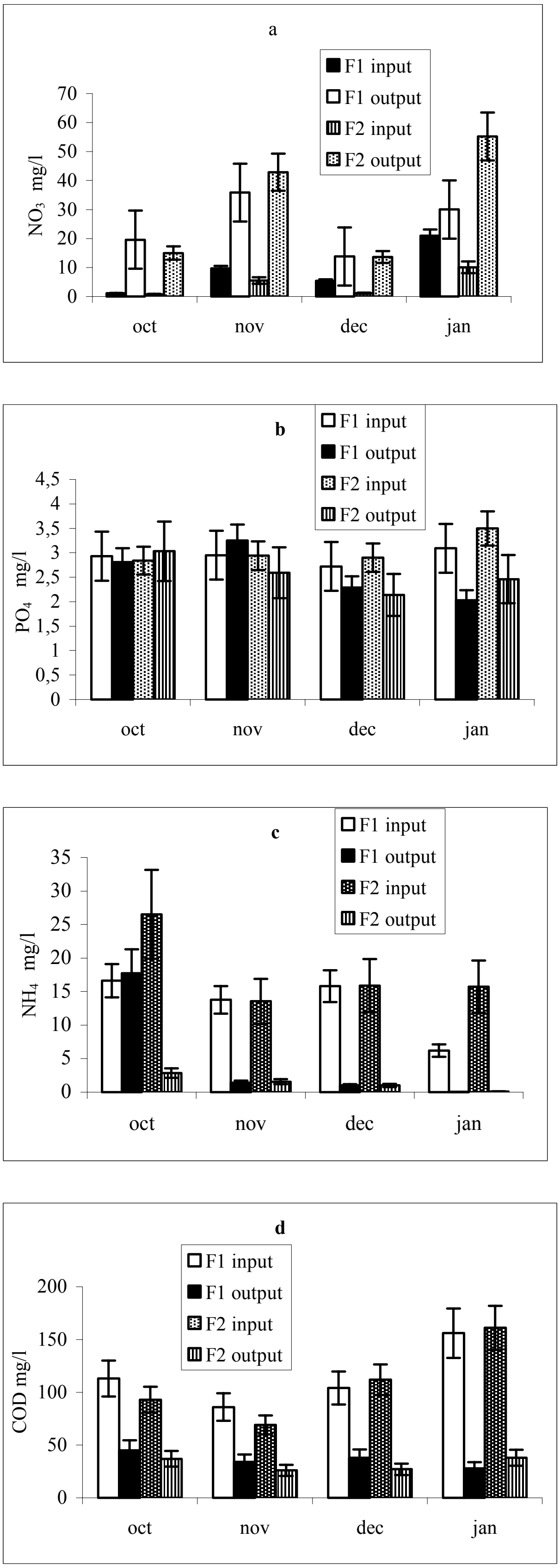

Fig. 1. Dynamics of chemical parameters: a – nitrate; b – phosphorous; c – ammonium; d – chemical oxygen demand (COD).

Thus, during October the dominant class size belonged to flocs within 100–200 µm range and their abundance was on average 30×103 flocs mL^{-1} (Fig. 2a). Little lower values were recorded during November ($12\cdot10^{3}$ flocs mL^{-1}) (Fig. 2b) and December ($13\cdot10^{3}$ flocs mL^{-1} sludge) (Fig. 2c). Another size classes were less obvious, flocs smaller than 50 µm with exception of only one analysis (during December when it was recorded of 30×10^{3} flocs mL^{-1}) were characterized by low frequency (Fig. 2b–e). Instead, flocs with 50–100 µm in diameter were abundant in December (27×10^{3} flocs mL^{-1} sludge). In general, our observations have indicated that the increased abundance of flocs higher than 100 µm occured in sludge with increased SVI, characteristic to bulking episodes. The average diameter of flocs varied from 146.42 µm (October) to 67.30 µm in diameter (December) and direct observations suggested that increased average diameter of flocs was accompanied by increased SVI value. Statistical analysis of the relation between size flocs, their abundance and SVI values has revealed two distinct situations. First, the abundance of flocs with 10–50 µm in diameter correlates negatively with increased SVI value (Pearson coeff. = –0.75). Same relation although more weak ($r = -0.51$) was observed between abundance of flocs with 50-100 µm in diameter and SVI. Instead, the relation is positive ($r = 0.79$) between abundance of flocs >100 µm in indicate that flocs >100 µm have a strong influence on the sludge settling properties and SVI values. Our observations based on analysis of relation between flocs size and chemical parameters has revealed two different situations. In the first case, the increase of phosphorous concentration correlates positively with the increase of SVI. This fact suggests that phosphorous plays a key role in promoting the bulking episodes. Since high concentrations of phosphorous could cause the increase the size of flocs, a potential mechanism of bulking control is to limit the level of this nutrient. Unlike phosphorous, the nitrate concentration seems to have a negative influence on the size of flocs ($r = -0.59$). This observation suggests that nitrate might inhibit the increase of flocs probably due to intermediate toxic compounds released during denitrification[18–20]. In this sense, one theory trying to explain the excessive growth of filamentous bacteria and bulking conditions considers that nitric oxide inhibits differently bacteria from activated sludge[21,22,23]. In our case, the effect of nitric oxide is indirect and limits the growth of floc formers and, thus, a reduced number of sites are available to support the growth of new flocs.

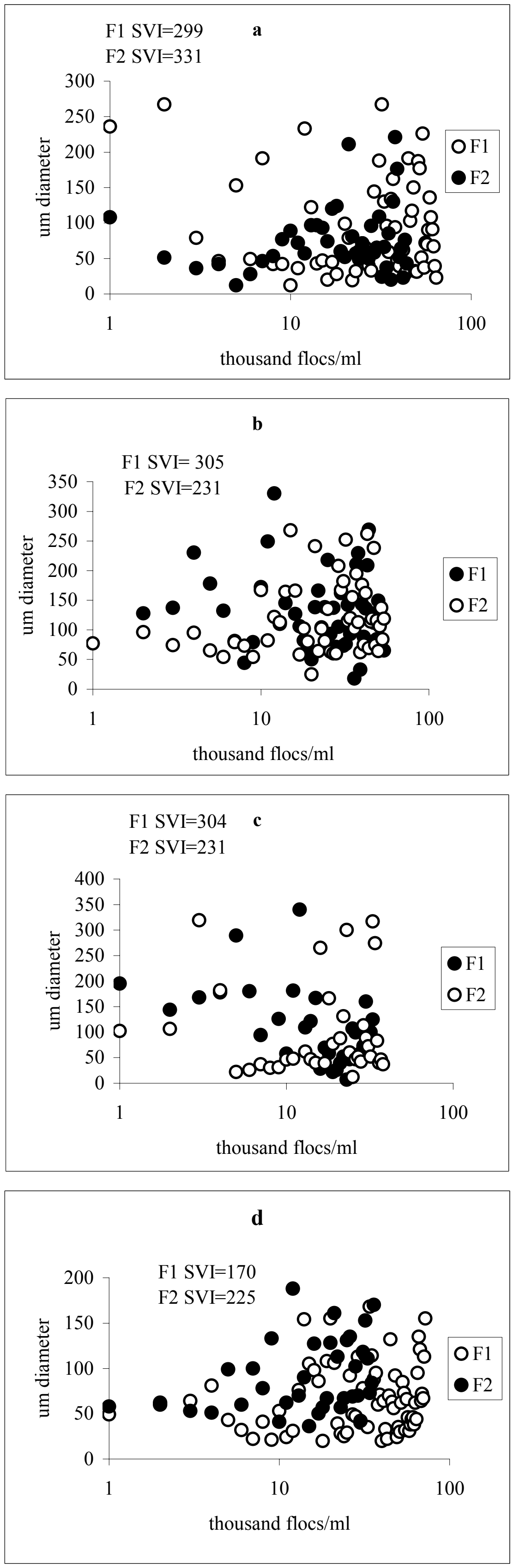

Fig. 2. Quantitative dynamics of sludge flocs; a – October; b – November; c – December; d – January; (SVI – sludge volume index).

CONCLUSIONS

Inorganic nutrients (nitrate, phosphorous, ammonium) and organic matter presented large quantitative fluctuations in all points of sampling, promoting the growth of a diverse microbial community. SVI overcame three times the optimal value and it was mainly driven by the increased abundance of flocs >100 µm in diameter. Our data indicated that wastewater rich in phosphorous stimulated the increase of flocs' size and favoured the bulking of activated sludge.

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