ABSTRACT

Today tanneries in India face the twin problem of managing process solid wastes and effluent treatment plant sludge. Considering the mean processing capacity, the process solid waste generated will be around in a tannery 1300 kg/day. In this, fleshings will account for 375 kg. Similarly, the effluent treatment plant sludge generated will be around 500 kg/day. The annual solid wastes generation i.e. fleshings and effluent treatment plant sludge will be 75 and 100 tonnes respectively. Every tannery faces this enormous problem of managing the disposal of 75 tonnes of fleshings and 100 tonnes of sludge annually.

Fleshings pose serious environmental threat. There is no reuse potential and disposal appears to be the only option available. Therefore, any method to reduce the quantum of fleshings waste to be managed would be a welcome message. Likewise, the treatment of effluent treatment plant sludge in a sludge digester demands huge investment cost. Technical options to economize on the design and operation of sludge digester will be of help to the tanners. Keeping these two specific needs, this research work has been planned.

Co-digestion of fleshings i.e. a process solid waste and the primary and the secondary sludges generated from the treatment of tannery wastewater has been demonstrated in the present study. Also the study illustrates the environmental and economic benefits arising out of such a process. From the
characterization studies, it was found that the substrates i.e. fleshings, the primary sludge and the secondary sludge are amenable for co-digestion and have a balance the carbon and nitrogen content present in the mixture of substrates.

In order to get the maximum benefit out of biogas generation, the mix proportion of the substrates was optimized and it was possible to generate a maximum of 385 mL biogas/ gram of VS_{added} for the mix proportion of 1.00:2.70:0.30. The biogas generation was enhanced by increasing the portion of primary sludge when compared with secondary sludge. Also it was observed that a residence time of 45 days is required for the co-digestion of tannery solid wastes. Further, the inoculum to substrate ratio, an important factor which influences the anaerobic digestion process, was optimized and a ratio of 1.0 was found to be the optimum.

With the inputs from the optimization studies, a detailed co-digestion studies were carried out using volatile solids input of 38, 45, 53, 60, 68 and 145 grams in order to study the effect of semi-continuous feeding of the organic matter on the co-digestion process. It was observed that at the volatile solids load of 68 grams per cycle the biogas generation per gram of VS_{added} was 470 mL. At this volatile solids load, the maximum percentage volatile fatty acid reduction was observed and hence the volatile solids load of 68 grams per cycle was found to be optimum. It was found from the performance evaluation data on volatile fatty acid to alkalinity ratio that the stable conditions prevailed during co-digestion of tannery wastes.
From the digestate analysis, the transformation of the functional groups (carboxylic acids, hydrocarbons, amines, alkynes and nitro compounds) present in the substrates and inoculum into secondary metabolites (primary, secondary and tertiary alcohols, amino acids, methane and ammonia) was observed which the same is the evident for the co-digestion process.

In order to increase soluble chemical oxygen demand in sludge samples, the effect of five pretreatment processes viz., ozonation, ultrasonication, peroxide treatment, alkaline treatment and alkaline thermal treatments were investigated. The ozonation was found to be the best pretreatment followed by alkaline thermal treatment and ultrasonication. Without actually going into the cost aspects in great detail, it is concluded that ozonation and ultrasonication are the two best options for pre-treatment. Co-digestion studies were carried out to assess the biogas generation without and with pretreated (ozonation and ultrasonication) sludges. The increase in biogas generation observed for ozonated and ultrasonicated pretreated primary and secondary sludges along with fleshings was 45 percent and 53 percent respectively when compared using sludges without pretreatment.

For the fat and lipid containing wastes, the rate of hydrolysis is slower than the other organic fractions present in the substrate. Enzyme application is an option to hasten the digestion process and in the present study one such enzyme namely steapsin, a commercial grade lipase, was used. Hence the present study also covers the effect of application of lipase on digestion process. Lipase addition reduced the residence time by 33 percent
for the generation of same volume of biogas in the control reactor. Hence, lipase addition helps in reducing the residence time thereby reducing the reactor volume.

In overall terms, the feasibility of co-digestion of fleshings along with the primary sludge and secondary sludge has been demonstrated satisfactorily for the first time.

In the event of implementation of the findings of the study in the field, the entire fleshings generated in the tannery on the daily basis can be utilized as the main substrate, thus the solving the problem of fleshings management. However, only a part of the primary sludge and secondary sludge generated in a tannery could be utilized as part of co-substrates. Hence, the remaining amount of the primary and secondary sludges requires appropriate management.