CHAPTER 6
SUMMARY AND CONCLUSIONS

6.1. SUMMARY OF THE STUDY

The sago processing industries produce high water pollution, as it generates large amounts of wastewater with high concentrations of organic pollutants and rich in carbohydrates, usually poses a problem for its disposal into the environment. The most widely used biological treatment process for domestic and industrial wastewaters is the conventional activated sludge process. However, the disadvantage of this process is high sludge production. The cost of handling, treatment and disposal of the excess sludge is about 40-65% of the costs of wastewater treatment. Uncoupling metabolism was developed as an alternative solution to decrease excess sludge production in sago processing wastewater, which seems to be feasible i.e., low-price, ease to control and non-toxic. Ozonation is an effective method for treating sago wastewater. Since ozone is a very powerful oxidant mainly used for disinfection process, and it has a strong cell lytic activity, which is also studied.

Aminophenol is selected as metabolic uncoupler successfully applied for reduction of excess sludge production. Studies were conducted to find the effect of process variables such as pH ($X_1$): 4-10, aminophenol concentration ($X_2$): 1-20 mg L$^{-1}$ and retention time ($X_3$): 20 days on analysed parameters such as VSS, MLSS, SS, COD, phosphate, nitrate, sulphate, carbohydrate and starch reduction in aerated and without aerated condition using RSM model for the optimization of the operating condition. Also studied the combined effect of these variables using statistically designed experiments. The statistical significance of the results
obtained were tested for ANOVA and it showed that the coefficient determination value, \( R^2 \) of VSS, MLSS, SS, COD, phosphate, nitrate, sulphate, carbohydrate and starch reduction were 0.7992, 0.8980, 0.8827, 0.9023, 0.8678, 0.9254, 0.8179, 0.9829 and 0.8819 respectively in aeration and 0.9867, 0.9319, 0.9474, 0.9175, 0.8234, 0.9584, 0.7716, 0.8832 and 0.7904 in without aeration. It indicates that the equation adequately represents the relationship between the response and the significant variables and \( F \) and \( p \) values shows that the statistically significant.

By applying RSM, the optimum values were calculated. Experimental findings were in close agreement with the model prediction. Maximum reduction of VSS (100%), MLSS (87%), SS (100%), COD (100%), phosphate (100%), nitrate (100%), sulphate (100%), carbohydrate (100%) and starch (100%) in aerated and without aerated condition showed maximum reduction of VSS (100%), MLSS (85%), SS (71%), COD (100%), phosphate (100%), nitrate (93%), sulphate (100%), carbohydrate (100%) and starch (100%) were achieved at acidic pH. At neutral pH, the efficiency of aminophenol was low when compared with that of acidic and alkaline pH. Variation of aminophenol concentration and retention time were highly effective for sludge reduction as well as parameters reduction. Maximum reduction was obtained under aerated condition while compare to without aerated condition. Model has been developed for observed growth yield (\( Y_{obs} \)) for calculating the sludge yield and maximum reduction on sludge yield was observed in with aeration. Further more aerated and without aerated samples showed less amount of microorganisms than control. From this study, it was concluded that reduction of sludge production in sago processing wastewater using metabolic uncoupler process is very effective and the variables
pH, concentration of aminophenol, and retention time were highly influenced the sludge reduction.

Ozonation process was successfully employed for reduction of excess sludge production. RSM model was used for the optimization of the operating condition for maximizing the VSS and COD reduction in ozonation condition. ANOVA results showed that the coefficient determination value ($R^2$) of VSS, MLSS, SS, COD, phosphate, nitrate, sulphate, carbohydrate and starch were 0.9689, 0.9252, 0.8148, 0.8838, 0.8681, 0.7516, 0.8982, 0.7991 and 0.8120 respectively. The $F$ and $p$ values of the variables shows that the statistically significant. By applying RSM, the optimum values were calculated. Experimental findings were in close agreement with the model prediction. Maximum reduction of VSS (81%), MLSS (68%), SS (84%), COD (87%), phosphate (65%), nitrate (84%), sulphate (85%), carbohydrate (100%) and starch (100%) were achieved at acidic pH, less ozonation time and retention time. Acidic pH has a greater influence for all parameters reduction. At neutral pH, the efficiency of ozone is low when compared with that of acidic and alkaline pH. Ozonation time and retention time influenced maximum sludge reduction, MLSS, SS and COD reduction. Ozonation process was highly effective for phosphate, nitrate, sulphate, carbohydrate and starch reduction. In addition, ozonated sample showed less amount of microorganisms than control. After 5 minutes ozonation, there was *Pseudomonas* spp. only observed. After 20 minutes ozonation, there was no microorganism was found in this study. It was concluded from this study that reduction of excess sludge production in sago processing wastewater by using ozonation process is very effective, and the variables pH, ozonation time and
retention time were highly influenced sludge reduction. Hence this study was a novel attempt for excess sludge reduction using ozonation process with RSM model, which helped to identify the most significant operating factors and optimum levels with minimum effort and time.

In the comparative study, Aminophenol with aeration is effective for sludge reduction when compared to without aeration and ozonation process. Aminophenol with aeration result showed maximum 100% reduction of VSS, SS, COD, phosphate, nitrate, sulphate, carbohydrate and starch were achieved. Maximum MLSS reduction was 87% in aerated condition. Without aerated condition and ozonation process were less effective than with aeration. It was concluded from this study that reduction of excess sludge production in sago processing wastewater by using aminophenol with aeration is very effective, and the variables pH, ozonation time and retention time highly influenced sludge reduction.

6.2. RECOMMENDATION FOR FUTURE RESEARCH

In this research, satisfactory results were obtained in sago processing wastewater using Aminophenol and ozone treatment. Further, Electrochemical treatment methods can be used to treat the sago processing wastewater for sludge reduction with respect to cost. Then, the efficiency of each method used to be compared for maximum sludge reduction. Finally, the cost efficient method to be scaled from lab scale to industrial scale is recommended.
REFERENCES


Davis, R.D., and Hall, J.E. (1997), Production, treatment and disposal of wastewater sludge in Europe from a UK perspective, European Water Pollution Control, 7: 9-17.


Gurak, R.S., McKillican, W.B., and Uppal, A. (1983), Extended solids residence time decreases biosludge disposal volumes from an oil refinery activated sludge plant, Water Pollution Research Journal of Canada, 18: 75-84.


Hogan, F.M., Mormede, S., Clark, P.B., and Crane, M.J. (2004), Enhanced anaerobic digestion using ultrasound. Proceedings, 10th World Congress Montreal, Canada.


Muller, J. (2000 a), Disintegration as a key-step in sewage sludge treatment, Water Science and Technology, 41: 123-130.


Murthy, Y.S., and Patel, M.D. (1961), Treatment and disposal of sago wastes, Central Public Health Engineering Research Institute, India.


Osagie, A.U., and Eka, O.U. (1998), Nutritional Quality of Plant Foods, Post harvest Research Unit, Department of Biochemistry, University of Benin, Benin City, 2-7.


Ratnam, B.V.V. (2001), Studies on physico-chemical and nutritional parameters for the production of ethanol from palmyra jaggery by submerged fermentation using Saccharomyces cerevisiae, PhD Thesis, Andhra University, Visakhapatnam, AP, India.


Satoh, H., Mino, T., and Matsuo, T. (1992), Uptake of organic substrates and accumulation of polyhydroxyalkanoates linked with glycolysis of intracellular
carbohydrates under anaerobic conditions in the biological excess phosphate removal processes. Water Science and Technology, 26: 933-942.


Stephenson, R.J., Laliberte, S., and Elson, P. (2004), Use of a high pressure homogenizer to pre-treat municipal biosolids: introducing the Micro Sludge process, Proceedings, 10th World Congress, Montreal, Canada.


Theodore, O., and Schafer, S. (2003), Sludge homogenisation as a means to reduce sludge volume and increase energy production, Ejeafche, 2: 1579-4377.


Wang, Z., Wang, L., Wang, B.Z., Jiang, Y.F., and Liu, S. (2008), Bench-scale study on zero excess activated sludge production process coupled with ozonation


Ye, F.X., and Li, Y. (2005), Reduction of excess sludge production by 3,3′4′5′-tetrachlorosalicylanilide in an activated sludge process, Applied Microbiology, 67: 269-274.


Ye, F.X., and Li, Y. (2010), Oxic-settling-anoxic (OSA) process combined with 3,3′4′5-tetrachlorosalicylanilide (TCS) to reduce excess sludge production in the activated sludge system. Biochemical Engineering Journal, 49:229-234.


Zhang, G., Yang, J., Liu, H., and Zhang, J. (2009), Sludge ozonation: disintegration, supernatant changes and mechanisms, Bioresources Technology, 100: 1505-1509.


mill effluent treatment in an up-flow anaerobic sludge mixed film bioreactor using response surface methodology (RSM), Water Research, 40: 3193-3208.