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Development and Performance Analysis of Two-Stage Biological Process Adopted in Sago Industries for Treatment of High Organic Effluent

P.S.Pandian[1], Dr.T.Meenambal[2]

AEE, O/o District Environmental Engineer, Tamilnadu Pollution Control Board, Namakkal, Tamilnadu, India[1]
Professor, Department of Civil Engineering, Government College of Technology, Coimbatore, Tamilnadu, India[2]
Email: pandiantnpcb@yahoo.com[1], tmeenambal_gct@yahoo.co.in[2]

Abstract- Sago industry is one of the major water consuming and polluting agro based industries which are prevalent in several parts of Tamil Nadu in India. These industries generate large quantities of high-strength organic effluent which requires proper treatment techniques prior to disposal. In this case, two-stage (anaerobic + aerobic) biological treatment processes are more suitable for treatment of high-strength organic effluent. The performance of anaerobic digester followed by aeration system adopted in various sago industries were observed and found that the chemical oxygen demand (COD) and biological oxygen demand (BOD) removal increased with increase in hydraulic retention time (HRT). The average percentage removals of COD and BOD in two-stage biological treatment are 85-90% and 90-95% respectively. In anaerobic digester, the production of biogas increased with increase in HRT at consent feed rate and recovery of biogas in the range of 55-60%.

Index Terms- Sago effluent, anaerobic digester, biogas, chemical oxygen demand, biological oxygen demand

1. INTRODUCTION

Water is an essential and basic human need for urban, industrial and agricultural use and has to be considered as a limited resource. In this sense, only 1% of the total water can be used for human needs. Inadequate water supply and water quality deterioration represent serious contemporary concerns for municipalities, industries, agriculture and the environment in many parts of the world. Factors contributing to these problems include continued population growth in urban areas, contamination of surface water and groundwater, uneven distribution of water resources and frequent droughts caused by extreme global weather patterns [1]. Discharging wastewater without treatment into surface water resources can affect the water quality and aquatic life negatively. Especially the amount and concentration of wastewater determine how they harm the intake habitation. In general, the sago industries are water intensive industries and it consumes more amount of water than metals and other chemical industries.

Sago industry is small scale industry in India and basically seasonal in nature, operating for only six months of the calendar year from September to March. In this industry, the tapioca roots are the raw material and it is converted into commercial starch/sago through indigenous technology that consumes huge amount of water. The sago industry produces starch/sago through debarking and processing of sago trunk, which generates high organic content effluent. In this process, the sago industry consumes 5-6 liters of water per 1kg of tapioca roots process and generates same quantity of effluent [2].

The major consumption of water in sago industry is mainly for washing roots and separation of free starch from fibrous pulp. The effluent from sago industry is characterized with a very high content of organic solid in dissolved and suspended state. The storage of sago effluent for some days results in obnoxious odors, lower pH and higher BOD & COD. This high organic effluent alters the characteristics of ecosystem when discharging into the environment without proper treatment [3]. Initially the farmers are used these effluents for irrigation and found that the growth, yield and soil health are reduced over a period. Similarly, sago industry effluent leads water pollution when discharged into water bodies. This high concentration effluent requires systematic treatment to reduce the pollutants content before disposal [4]. The State Pollution Control Board of Tamil Nadu, India, has directed the industries to implement zero discharge facilities.

An organic pollutant present in sago effluent is treated by physico chemical and biological methods. Physical and chemical processes are quite expensive and generate a considerable amount of sludge which itself needs further treatment. The biological treatment processes are more suitable for treatment of high-strength organic effluent when two-stage (anaerobic + aerobic) treatment technique is used [5]. The objective of this paper is to study the biological treatment methods adopted in various sago industries located in Salem District to reduce the organic pollutants in effluent and disposal method.

2. EFFLUENT GENERATION FROM SAGO INDUSTRY AT VARIOUS PROCESS STAGES

In sago manufacturing process, the tapioca roots are washed with water to remove adhering dirt and the washed roots are fed into mechanical tuber peeler to remove skins. The peeled roots are put in a concrete tank, where they remain immersed in water until taken out for rasping. The peeled roots are subjected to high pressure water jets during conveying for rasping. It is necessary to rupture cell walls in order to release the starch granules. Rasping facilitates rupture of cell walls and release of starch granules. This is carried out by pressing the roots against a swiftly moving surface provided with sharp protrusions. A large quantity of water is added to the roots during this process.

After rasping, the pulp is screened in the shaking screens. In separating the pulp from the free starch, a liberal amount of water is added to the pulp as it is delivered by the rasper and the resulting dispersion is stirred vigorously before screening. The fresh pulp after mixing with water in distribution tanks is transferred by pipes to the higher end of the screen. During screening, the dispersion passes through a set of screens with increasing fineness, the first one retains the coarse pulp, the others the fine particles.

After the separation of starch by screening, the starch milk is subjected to a settling process. The starch milk is pumped to a tank fitted with effluent outlets at varying heights. Settling takes about 6 to 20 hours depending on the quantity as well as the size of the settling tank. Settling is an important unit operation in cassava processing where the extracted starch is separated from its aqueous dispersion under gravity. The upper layer of sediment flour, which has a yellowish green tint, contains many impurities and is generally scraped off and discarded. The remaining moist flour is then stirred up with water and transferred to another tank where starch is settled. The final settled moist floor is removed by using a crowbar.

Then the extracted starch is subjected to globulation in vibratory units provided with gunny cloth surfaces forming two pouches. Each pouch or sack can hold 10 to 12 kg of wet starch powder for globulation. The globulated starch powder is then graded in oscillating screens and the granule of sago is formed. After formation of sago, it is given a mild roasting on hot plates at about 100°C for about 6 to 8 minutes. The roasted sago is then dried in the sun on cemented floor for about 8 to 12 hours depending on the intensity of sun shine. During roasting, the sago lumps are formed which passing the material through disintegrate breaks down. The sago from drying section is passed through the polishing machine. Here the sago lumps are breaks down and get uniform polish. The polished sago is passed through the vibrating screen to get different uniform sizes. Then the sago is finally packed in jute bags. The effluent which is generated from roots washing, peeled roots washing and starch extraction section contains mainly organic matters, suspended solids, fibers etc [6]. The processing of sago requires several washing cycles and generates 30000–35000 liters of effluent per ton of sago production. Fig.1 shows the effluent generation at various stages of sago processing.

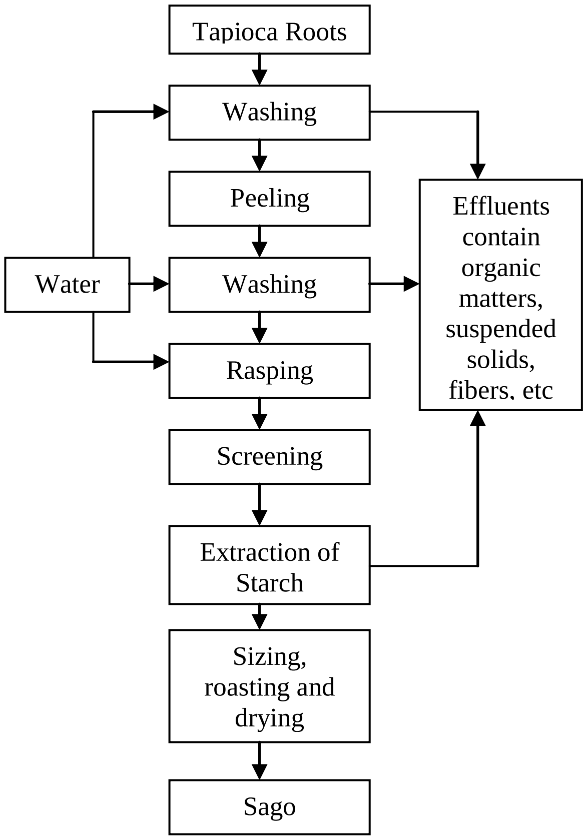

Fig.1 Effluent generation at various process stages

3. CHARACTERISTICS OF RAW SAGO EFFLUENT

The Characterization of effluent from various sago industries located in Salem District indicates that the effluents arising are very acidic in nature with BOD/COD ratio in the range of 0.6-0.7 and it is highly biodegradable because of its high organic content. The physiochemical parameters like pH, Total Suspended Solids, Total Dissolved Solids, Biological Oxygen demand, Chemical Oxygen Demand, Oil and Grease and Chlorides are presented in Table 1.

Table 1: Characteristics of sago effluent

Parameters	Values
Ph	5-7
Chemical Oxygen Demand (mg/l)	5000-7000
Biological Oxygen Demand (mg/l)	2000-3500
Total Suspended Solids (mg/l)	900-1100
Total Dissolved Solids (mg/l)	4000-4500
Chloride (mg/l)	200-500
Oil and Grease (mg/l)	5-7
Sulphates (as SO_4) (mg/l)	500-550

4. MATERIALS AND METHODS

4.1. Sample collection

A sample of raw effluent from various sago industries located in Salem District were collected and analyzed with the help of Advanced Environmental Laboratory, Tamilnadu Pollution Control Board. The raw effluent was collected in a 10 litre sterilized plastic can from the effluent disposal system of the sago industry.

4.2. Analytical procedures

The chemical oxygen demand, biochemical oxygen demand, total suspended solids, total dissolved solids, chlorides and sulphates analysis were carried out by procedures described in standard methods [7]. The pH was measured using Elico LI120 model pH meter.

5. Discussion

5.1. Development of treatment system in sago industries

Initially the sago industries located in Salem District were utilized the generated effluent on land for irrigation without treatment. Due to stringent environment protection regulations, it is necessary for the processing industry to treat effluent. Physical and chemical methods of treating the sago effluent have been unpredictable due to the problem of sludge disposal. Biological methods are classified into two types: aerobic processes, which have limited applicability due to aeration cost, and anaerobic processes at high treatment rate.

Then sago industries were implemented the sequence of aeration system to treat the effluent depends upon the quantity of effluent generation. The treated effluent from aeration tank is passed through settling tank for removal of digested biomass and treated effluent was utilized on land for irrigation. In this process, the sago industries were achieved the removal efficiency of COD and BOD in the rage of 80-90% but this process consumed huge amount of powder to supply oxygen and the operating cost was high. Due to this, the sago industries were introduced the anaerobic lagoon system before the aeration system to reduce the load for aerobic bacteria and to reduce operating cost. In anaerobic lagoon followed by aeration system, the industries were achieved the removal efficiency of COD and BOD in the range of 85-95%.

But the anaerobic lagoons are not applicable to many situations because of large land requirements, sensitivity to environmental conditions, and objectionable odors. Furthermore, the anaerobic process may require long retention times, especially in cold climates, as anaerobic bacteria are un-effective below 15°C. Methane gas is potential one and it released from the lagoon and mixed with atmosphere without any use [8]. After that the sago industries were provided the anaerobic digester along with gas recovery system followed by aerobic process.

5.2. Performance of anaerobic digester and aeration System

The performance of anaerobic digester followed by aeration system adopted in various sago industries located in Salem District were studied. The COD, BOD and pH were monitored in anaerobic digester over a period of 18 days. From the observation, it was found that the COD and BOD removal increased with increase in HRT at consent fed rate up to 12 days after that the less removal efficiency was observed when increase in HRT. The effect of HRT on COD and BOD reduction is shown in Fig.2. The average percentage removals of COD and BOD in anaerobic digester are 85% and 90% respectively [9,10] and also found that the pH of effluent increased with increase in HRT at consent fed rate up to 12 days after that no significant effect in pH when increase in HRT and the effect of HRT in pH is shown in Fig.3.

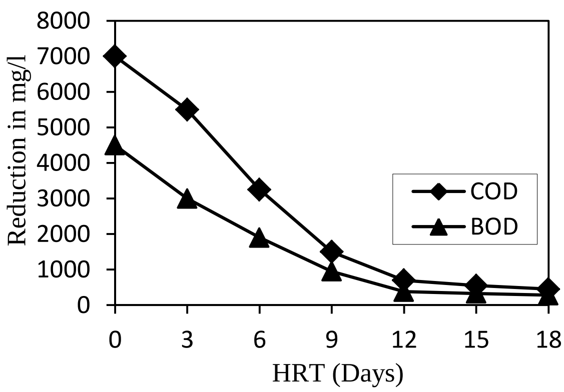

Fig.2 Reduction of COD and BOD

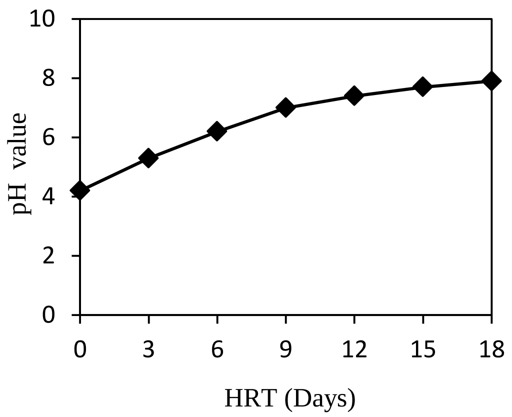

Fig.3 pH value Vs HRT

The cost-effective method for treatment of sago effluent is biogas recovery. In anaerobic digester, the production of biogas increased with increase in HRT at consent feed rate and recovery of biogas in the range of 55-60%. Biogas is an excellent energy source. Treatment cost is also very less in the case of anaerobic system [11,12]. The recovery of biogas from effluent of sago can replace the use of firewood and coconut shell for roasting and drying of sago, which reduce the cost of production and improve the quality of product. The alternative method for utilization of biogas is electricity production. In sago industries, the treated effluent from anaerobic process is further treated in aerobic process. In aerobic process, the average percentage removal of COD and BOD increased with increase in HRT at consent feed rate. The average percentage removals of COD and BOD in aerobic process are 90% and 95% respectively. After treatments, the effluent has a much lower COD, BOD and TDS and the treated effluents utilized on land for irrigation. The table 2 summarizes the characteristics of treated effluent in sago industries with Tamilnadu Pollution Control Board (TNPCB) norms.

Table 2. Summary of effluent characteristics

Parameters	**Effluent characteristics value after anaerobic treatment**	**Final Treated sago effluent**	**Irrigation standards prescribed by TNPCB**
pH	6.5-7.0	7.5-7.8	5.5-9
Chemical Oxygen Demand (mg/l)	750-800	180-200	250
Biological Oxygen Demand (mg/l)	380-400	30-50	100
Total Suspended Solids (mg/l)	320-350	180-190	200
Total Dissolved Solids (mg/l)	2500-2800	1800-2000	2100

6. CONCLUSION

The high BOD and COD content of sago industry effluent pose serious threat to environment and untreated effluent causes damage to crop growth when utilizing on land irrigation. The treated effluent is less toxic, when compared to the untreated effluent because the integrated treatment system for effluent following anaerobic and aeration reduces the pollution load. The effluent generated by most agro based industries is organic in nature and anaerobic digestion is the way to combat pollution. From this study, it was observed that the average percentage removals of COD and BOD in anaerobic followed by aerobic process are in the range of 85-90% and 90-95% respectively. The treated effluent characteristics were within standards prescribed by the Tamilnadu Pollution Control Board and can be considered as a source of water for agricultural use. Biogas recovery from effluent treatment system has shown great potential for tapioca starch processors and digested slurry from anaerobic system can be used as manure.

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