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# A prototype of proposed treatment plant for sago factory effluent

Sivasubramanian Savitha [a,*], Subramaniam Sadhasivam [a], Krishnasamy Swaminathan [b], Feng Huei Lin [a]

[a] Institute of Biomedical Engineering, College of Engineering, National Taiwan University, Taipei 100, Taiwan
[b] Microbial Biotechnology Division, Department of Biotechnology, Bharathiar University, Coimbatore 641 046, Tamil Nadu, India

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ABSTRACT

Sago processing industries discharge wastewater, which poses a threat to water bodies due to their higher organic loading. Concerns about pollution related problems in the global scenario are persuading all the processing industries to adopt cleaner manufacturing practices. Hence, this study was aimed at developing a cost-effective and eco-friendly treatment plant based on microbial system to treat the sago factory effluent effectively in order to reuse the water for industrial purposes. The experimental results showed that, anaerobic treatment with mixed inoculum for 10 days followed by 6 days of fungal treatment was found to be effective in effluent treatment. The fusant showed a higher efficiency in the treatment of sago factory effluent than the parental strains.



## 1. Introduction

Sago, the edible starch in the form of globules is manufactured from tapioca tubers (*Manihot esculenta*). Tapioca tubers are an important source of starch and also serve as staple food. In India, nearly 60% of cassava is used industrially in the production of sago, starch and dry chips. The crop is concentrated in the southern peninsular region of India in an area of 0.246106 ha producing 6.76106 t with the highest average productivity of 27.92 t/ha in the world [1]. By virtue of its diversified uses, cassava has become an important commercial crop in the agricultural economy of states like Tamil Nadu and Andhra Pradesh, India.

In the southern region of India alone there are about 1000 sago and starch processing factories producing 15–30 t of sago per unit per day. Extraction of starch from cassava consists of washing of tubers, mechanical peeling, rasping, grinding, sieving, regrinding, sieving and dewatering process that involves voluminous amount of water. These units discharge about 40,000–50,000 L of sago effluent per tonne of sago processed and it takes about 10 days for the water to be let out of the factory as effluent [2]. The sago processed water being rich in carbohydrates, usually poses a problem for its disposal into the environment. Most of the low cost and some conventional treatment methods reported to have low treatment efficiency due to high concentration of suspended solids, unextracted starch, cellulose, carbohydrates, nitrogenous compounds and cyanoglucosides and insoluble fibres present in the effluent. Conventional treatment plants are rarely operated in starch factories, probably because of requiring a high energy input. Similarly, the utility of physical and chemical processes has been limited due to their expensive operation and subsequent disposable problem of generated chemical sludge. All conventional treatment methods used for the treatment of industrial waste are associated with its own inherent drawbacks which limit their practical application. For instance, precipitation chemicals are costly and cannot be recovered, thereby adding a significant cost to the system. Besides, membrane based separation is cost-effective and often conditioned by difficult plant management as they require a careful control strategy. Trickling filters are susceptible to environmental stresses and clogging problems. These are labor-intensive and time consuming processes and these technologies turned out to be costly and unreliable [3]. At-source treatment by biological method [4] has an ample scope and may be a cost-effective option compared with other chemicals owing to its high efficiency in reduction of biological oxygen demand (BOD) and chemical oxygen demand (COD), employing microbes and reducing the chemical and plant installation cost. Currently, there is a strong tendency toward the use of methodologies for controlling pollution at source, particularly through wastewater reuse and/or recycling [5].

Cassava processing is generally perceived as polluting the environment; very little research has been conducted to quantify the levels of pollution and determine the magnitude and significance of

* Corresponding author. Tel.: +886 02 2364 1541; fax: +886 2312 3456.
*E-mail address:* savisbio@yahoo.com (S. Savitha).

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this pollution on people and the environment. Also, little research has been conducted to develop efficient and cost-effective ways to reduce pollution, especially by small and medium size processors. Given that suitable technologies are available or can be developed, the problems of pollution from cassava processing are more social and economic in nature than technological. Most governments recognize the need to control waste produced by cassava factories, but they are equally aware of the economic risk involved in such a strategy.

Most of the waste from cassava processing is discharged without any treatment. Some factories store the effluent in settling tanks for a number of days before discharge; in this case, BOD around 2500–3000 mg $L^{-1}$ would be the largest and most significant environmental impact [6] and COD around 5000–7000 mg $L^{-1}$ levels [7] are reduced and most cyanide evaporates. The present studied starch factory has no highly equipped treatment system to discharge waste but treats the wastewater with compounds such as alum to precipitate the suspended solids and reduce BOD before disposal which may pose a severe threat to the land and plants under irrigation and hence our newly developed technology employing anaerobic technology with fungi mediated treatment could effectively reduce the BOD and COD level to permissible levels thus allowing the factory to set up a eco-friendly and effective treatment plant with low cost. The main advantages of anaerobic wastewater treatment have always been its potential of methane production and its low excess sludge yield.

The intrinsic requirement of any agricultural policy for commodity development is to understand the structure of demand for those products. Authentic information to understand the current demand, projected future demand, supply prospects from industry side are essential to develop a suitable policy for meeting the projected demand–supply gap, if any. Demand for cassava starch is being influenced by many factors such as governmental policy on the industries where cassava starch finds application, availability of cheaper substitutes and fluctuating growth of the industries using cassava starch, population growth and international trade.

The cost of effluent treatment processes will finally end up in increased price on the industrial product, which may affect the consumers in turn. Instead, if the wastewaters produced in these industries are properly treated by cost-effective methods to reduce the pollution load to the level below Bureau of Indian standards (BIS) [8], the water can be treated in a cheaper way and it could be recycled either for raw material processing or for irrigation purposes. To improve industrial water use, water quantity and quality need to be considered [9]. Moreover, there is a lack of knowledge in sago industries on the treatment process from a technical point of view. Owing to both economic and technical advantages, in this investigation, an attempt has been made to design a cost-effective and eco-friendly technology/treatment plant via., biological treatment with fungi *Graphium putredinis*, *Trichoderma harzianum* and fusant to treat the sago factory effluent. To our knowledge, this is the first detailed report on the treatment of sago effluent employing the fungus, *G. putredinis*. The efficiency of the treatment process was analyzed by phytotoxicity studies using *Zea mays* Co1 seeds as test system. The digested sludge obtained during the treatment process was utilized for biogas production. The nutrient value of the sludge was analyzed in order to test the feasibility of using it as a fertilizer.

## 2. Materials and methods

### 2.1. Microbial source

For selection of microorganisms, amylase enzyme was used as the marker enzyme. The microorganisms were isolated from effluent samples collected near the sago industries situated at Ammanpalayam, Kattukottai, Thalaivasal, Nathakarai, Pattuthai, Siruvadi and Veppanatham of Atthur and Kallakurichi taluks of Salem districts, Tamil Nadu, India.

### 2.2. Inocula

The inocula used in the present study to treat the sago factory effluent were

1. The fungi, *G. putredinis*, *Trichoderma harzainum* and their fusant [10], grown in Czapek Dox agar medium.
2. Activated sludge collected from sewage treatment plant, Coimbatore Municipal Corporation, Coimbatore, Tamil Nadu, India.
3. Cow dung slurry from a local biogas plant.

#### 2.2.1. Selection and optimization of inoculum and treatment period

The sago factory effluent was taken in digestion bottles and inoculated with various concentrations (10, 20, 30, 40 and 50% v/v) of the inocula (activated sludge, cow dung slurry and a mixture – 1:1 v/v – of these two) and incubated under aerobic and anaerobic condition at $27 \pm 2$ °C for 10 days and analyzed for pollution parameters. To determine the optimum treatment period, selected inoculum at its optimum concentration was inoculated into effluent and incubated for 20 days both under aerobic and anaerobic conditions and the samples were withdrawn at regular time intervals of 2 days. The pollution parameters analyzed were pH, starch, turbidity, BOD and COD. The mixed inoculum (1:1 v/v) at 40% concentration was found to be more effective in reducing the pollutant levels in the effluent and hence it was used for further studies.

### 2.3. Treatment process

The sago factory effluent was subjected to the following treatments at $27 \pm 2$ °C.

Treatment 1 ($Tr_1$): Aerobic treatment with mixed inoculum for 10 days incubation period.
Treatment 2 ($Tr_2$): Anaerobic treatment with mixed inoculum for 10 days incubation period.
Treatment 3 ($Tr_3$): Fungal treatment: one set of effluent bottles was amended with nutrients such as, 1% glucose, 0.05% $KH_2PO_4$, 0.05% $MgSO_4$ and 0.3% $NH_4NO_3$ and inoculated with spore suspension ($10^6$ spores $mL^{-1}$) of the test fungi. The bottles were aerated for 10 days. The other set of effluent bottles without the amendment of nutrients was inoculated with spore suspension of the test fungi ($10^6$ spores $mL^{-1}$) and aerated for 10 days. The incubation period of 6 days was found to be optimum for effluent treatment.
Treatment 4 ($Tr_4$): Aerobic + fungal treatment: the aerobically treated effluent ($Tr_1$) was subjected to fungal treatment ($Tr_3$) for 6 days.
Treatment 5 ($Tr_5$): Anaerobic + fungal treatment: the anaerobically treated effluent ($Tr_2$) was further subjected to fungal treatment ($Tr_3$) for 6 days.
Treatment 6 ($Tr_6$): Fungal + aerobic treatment: the fungal treated effluent ($Tr_3$) was further subjected to aerobic treatment ($Tr_1$) for 10 days.
Treatment 7 ($Tr_7$): Fungal + anaerobic treatment: the fungal treated effluent ($Tr_3$) was subjected to anaerobic treatment ($Tr_2$) for another 10 days.
Treatment 8 ($Tr_8$): Combined fungal and aerobic treatment.

The effluent was treated with mixed inoculum (activated sludge:cow dung slurry, 1:1 v/v) at 40% concentration along with fungal spore suspension ($10^6$ spores $mL^{-1}$) for 6 days under aerated