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Original Research Paper

Scope of Carbon Trade in Sago Industry

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ABSTRACT

Tapioca sago manufacturing is one of the chief food industries in the southeast Asia. The starch/sago industry is an agrobased seasonal industry using tapioca roots/tubers as the basic raw material. The process of production of sago and starch from tapioca is water intensive. The waste from sago factories contains both water effluent and solid wastes. Cyanide concentration in the effluent is at alarming level, which requires an urgent attention for its removal. From the effluent of the sago industry many by-products such as methane, ethanol and alcohol can be produced. The methane gas generated and accumulated from sago effluent is being used by the industry for thermal and electrical applications. Global warming potential (GWP) of methane (CH_4) is very high which is 21 times that of carbon dioxide. Accordingly, methane recovery from sago effluent serves good both in terms of reduction in power consumption sourced from fossil fuels and reduction in global warming potential. At this outset, this paper is aimed to explore the prospects of clean development mechanism in the matter of sago production.

INTRODUCTION

Tapioca sago manufacturing is one of the chief food industries in the southeast Asia. The starch/sago industry is an agrobased seasonal industry using tapioca roots/tubers as the basic raw material. Sago and starch production is mainly done under the category of small-scale industries. Of the total area under the tapioca cultivation in India, 61 percent is contributed by Kerala, 29 percent by Tamil Nadu, 9 percent by Andra Pradesh and the rest by the other states.

Though Kerala ranks first in the area under cultivation of tapioca, Tamil Nadu ranks first in the processing of tapioca into the sago and starch. It meets about 80 percent of the country's demand. The estimated total area under tapioca cultivation in Tamil Nadu is about 1.1 lakh hectares with an annual production of 40 lakh tons showing an average productivity of 38 tons/ha, which is highest in world. It employs about 5 lakhs of people both directly and indirectly.

Sago industry is one of the small-scale industries, which facilitates rapid development of any region. The Salem and Namakkal districts in Tamil Nadu enjoy the monopoly in sago and starch production in the whole nation. The large consuming sectors of the tapioca sago and starch are food industries, cattle feed manufacturing, adhesive manufacturing, chemicals like dextrin manufacturing, and sizing units in textile industry. Sago units are concentrated in Salem, Attur, Rasipuram and Namakkal taluks (Balagopalan & Nanda 2000).

Sago is a close alternate for wheat and rice in the diet of many, especially in north India. It is a globules prepared out of tapioca. On an average, the yield of sago is 200 kg per ton of tapioca roots processed. The manufacturing process of sago consists of washing, peeling, crushing, slurring, settling, sizing, roasting, drying and polishing. In the world production of starch, 77 percent is produced from maize, 8 percent is produced from tapioca and the rest from the other crops. About 1.4 lakh tons starch is produced in India and the contribution from tapioca is about 8.3 percent.

In view of the use of wastes produced from sago industry in production of energy, it is possible to earn carbon credits from it. The paper deals with the pollution load created in sago industry and possiblity of earning carbon credits from it by production of energy.

ENVIRONMENTAL IMPLICATIONS OF SAGO INDUSTRY

The process of production of sago and starch from tapioca is water intensive. Of the entire production practice, processes like wet washings of tapioca, sago milk extraction and sago milk refining are water demanding. Wastewater is rooted out from washing of roots with skin, washing of peeled tubers and supernatant from the settling tanks, where the sago is settled. On an average, the sago industry generates 30,000 to 40,000 litres of effluent, per ton of sago produced. The sago effluent is oxygen demanding and acidic in nature, containing a BOD in the order of 2500-4000 mg/L. Presence of suspended solids is also significant in the effluent that settles in the water stream and loots the aquatic culture. Organic load in the effluent leads to an immediate growth of the various microorganisms. It causes the release of severe odour, which resembles the smell of sulphuric acid.

The presence of inorganic constituents like phosphate, sulphate, chloride, cyanide, etc. in sago effluent is also significant. Some metals like sodium, potassium, iron, etc. are also found in trace quantities. The colour of the effluent is firstly brown and then becomes black. Sago factories may discharge their effluents to nearby drainage channels, fields, ponds, lakes and rivers. Understandably, high-level concentration of BOD, COD and cyanide is harmful to the surrounding environment.

Groundwater sources nearby sago factories are polluted with cyanogens. Untreated wastes are harmful to the crops cultivated in the nearby agricultural lands. However, treated wastewater serve up good for the growth of crops. Major components of waste from sago factory are given in Table 1.

The waste from sago factories contains both water effluent and solid wastes. Cyanide concentration in the effluent is the alarming fact, which requires an urgent attention to curb.

Solid waste: The peeled skin of tapioca and the residue of crushed tuber after the extraction of sago make up the solid waste. The peelings are compostable and, thus, have manure value. The residue including fibres, knots, etc. are known as 'Thippi'. The solar dried Thippi is used as cattle feed. The wet Thippi while dried in sun may release attached water, which is also a strong waste containing high BOD and mineral matters.

Hydrocyanic acid content: A mixture of hydrogen cyanide solution in water is called hydrocyanide. It is a colourless or pale blue poisonous liquid. It is a very weak acid that boils slightly above room temperature at about 26°C. It has faint, bitter and almond like odour, which may not be noticeable to some people due to a genetic trait. Some fruits and tubers like cherries, apricots, almonds, apples and cassava tubers contain meagre amount of HCN naturally. The cassava roots usually contain a small amount of hydrocyanic acid (HCN), which however disappears when they are processed for extracting starch. The bitter variety contains more hydrocyanic acid than the sweet variety. The acid, formed by the action of enzyme on a glucoside, phaseolutain, is present to the extent of 0.01-0.035 percent in the tubers of bitter manioc. Of the total HCN, 85 percent is in the skin and the remaining 15 percent in the tubers. On drying in the sun, content of hydrocyanic acid falls to 0.0017 percent and in oven dried to 0.006 percent. In the process of making tapioca starch, the formation of hydrocyanic acid is removed as far as possible because, when liberated it forms blue iron. Thus starch will take blue colour (Sangeethmohan 2000).

The hydrogen cyanide is the major harmful substance. Cyanogenic glycosides are highly toxic in the inadequately processed or detoxified plant products like cassava, because of the release of hydrogen cyanide. The presence of cyanogenic glycosides in different varieties of cassava is given in Table 2.

Table 1: Components of waste from sago factories.

Name of the component	Quantity of the waste
Wastewater	16-20 m^3/ton of sago produced
Peelings	50-60 kg/ton of tubers peeled
Solid residues	50-70 kg/ton of sago produced

Source: http://www.ctcri.org/

Table 2: Presence of cyanogens in cassava varieties.

Cassava varieties	Presence of cyanogens (in mg/kg)
Cassava (bitter)/dried root cortex	2360
Cassava (bitter)/leaves	300
Cassava (bitter)/whole tubers	380
Cassava (sweet)/leaves	451
Cassava (sweet)/whole tubers	445
Gari flour (Nigeria)	10.6-22.1

Source: http://www.inchem.org/

The presence of cyanogenic glycosides in plants depends upon many factors like genetic and environmental factors, location, season and soil types. The cyanogenic glycoside content of fresh tapioca varies from 15-400 mg of cyanide per kg. Some bitter varieties of cassava tubers restrain cyanogens in the extreme range of 1300-2000 mg/kg. The presence of cyanogens in cassava leaves range from 1000-2000 mg/kg. Long-term consumption of cassava with high levels of cyanogenic glycosides has tended to cause ailments like tropical ataxic neuropathy, spastic paraparesis, hypothyroidism, goitre and cretinism. Its impact is potential on those humans with malnutrition, low protein content of the diet, vitamin deficiencies and iodine status (Ojo Omorogieva & Rashid Deane 2002). The toxicity of cyanogenic glycosides in animals and man is often expressed as mg releasable cyanide. The cyanide level in different human tissues in a fatal case of HCN poisoning has been reported as gastric content; 0.03, blood; 0.50, liver; 0.03, kidney; 0.11, brain; 0.07 and urine; 0.20 mg/100 g (Speijers 1992). Inadequate processing of cassava has been highly associated with higher concentration of cyanogens. In rare cases intake of inadequately processed cassava may lead to deaths like death of whole families (Cliff & Countinho 1995). In the year 2005 March in Mabini town, twenty-seven children aged 7 to 13 died and more than 100 others fell ill, after eating the sweet sugar-coated maruya made of inadequately processed white cassava sold at the gates of an elementary school in the central island of Bohol. However, later on it was doubted that organophosphate, a pesticide might be the cause of the poisoning (http://www.bohol.gov.ph/). The impact of cyanogens in cassava would be vulnerable on children with low body weight, which may cause even death.

TREATMENT AND ENERGY PRODUCTION FROM SAGO INDUSTRY WASTE

Treatment methodology: The primary goal of wastewater treatment is to make the available source of water supply suitable for the particular end use (Ramachandran 1986). Traditionally, sago industry produce liquid effluents which are stored in anaerobic lagoons with eventual overflow and discharge into public waterways. Alternatively they provided with mechanically aerated aerobic (secondary) treatment before discharge (Belliappa 1989). The treatment process of the effluent from sago and starch factories involves the mechanism of collection tank, anaerobic digester, aeration tank, settling tanks, sludge drying bed and sand filter.

Energy recovery from effluent: From effluent of the sago industry many by-products such as methane, ethanol and alcohol can be produced. The methane gas generated and accumulated from sago effluent is being used by the industry for thermal and electrical applications.

Methane is a colourless, odourless gas with a wide distribution in nature. It is the principal component of natural gas. Anaerobic bacterial decomposition of plant and animal matter occurs under water, produces marsh gas, known as methane. Methane is not toxic when inhaled, but it can produce suffocation by reducing the concentration of oxygen inhaled. The energy released by the combustion of methane, in the form of natural gas, is used directly to heat homes and commercial buildings. It is also used in the generation of electric power. At present, in India there are about 6.1 lakh biogas plants.

Sathyanarayanan, President and Former UNDIO Expert, The Salem, Dharmapuri Chamber of Commerce, Salem has invented a methane generation plant from the sago effluent. He had found that the starch bearing wastewater can effectively be treated using anaerobic digestion systems and it is possible to produce methane. Based on the preliminary design calculations, it is found that 500 tons of tapioca can generate approximately 2MW. In this way all the 450 sago units in Salem and Namakkal districts could generate 45MW, with least capital cost and without any fossil fuel (Sathyanarayanan 2000). He found the inexpensive method of collecting methane from lagoons by using plastic sheets to cover over effluent tanks and it was found that the plastic sheets were bulged within few minutes. The effluent water, after necessary treatment can be used for aquaculture applications, that is to grow high yield fish *Tilapia*. An international award was given to the Salem, Dharmapuri Chamber of Commerce by the Association of Energy Engineers, Atlanta, Baltimore, U.S.A. for having identified that the effluent gas is methane.

In the treatment process, the wastewater to be treated is introduced in the bottom of the anaerobic digester (Fig. 1). The wastewater flows upward through a biologically formed granules or particles. Treatment would take place when the wastewater comes in contact with the granules. The gases produced under anaerobic conditions, CH_4 and CO_2, cause internal circulation, which helps in the formation and maintaining biological granules. The gas produced under anaerobic conditions, CH_4 and CO_2, is collected by using plastic sheets to cover the effluent tanks. The plastic sheets will bulge in few minutes by accumulation of methane gas. This methane gas is converted into power by using the simple converter systems. The cost-benefit analysis of the energy production from sago industry waste is given in Table 3.

It is clear that there would be a substantial reduction in expenditure on electricity by the factory, if they attempt to produce biogas from the effluent. Due to this there would be a net savings of Rs. 13.31 lakhs. At present factories are using DG sets for conversion of biogas into electricity. If a specially designed gas turbines such as micro turbine will be used for conversion, it may replace the total electrical energy requirement. But this is a costly affair and that is why MNES has undertaken 20 detailed projects to provide an interest subsidy of @ 7.5% to the plants having a crushing capacity of 100 to 150 tcd. In such case it is possible to generate 13.6 MW with an investment of Rs 50 crores.

CLEAN DEVELOPMENT MECHANISM (CDM)

Carbon trade is a managerial approach to control pollution by providing monetary incentives known as carbon credits for attaining reduction in emission of the pollutants.

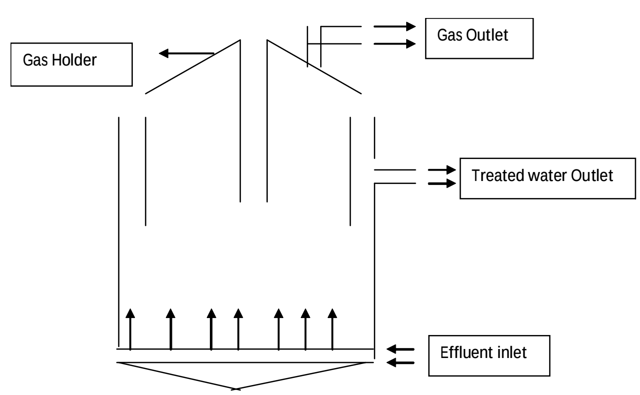

Fig 1: Outline of the reactor for extracting biogas from effluent.

Table 3: Cost-benefit analysis of energy production from sago industry waste.

Cost and Benefit Ratio		
A. If the factory runs by electricity		
Crushing capacity of the unit	:	50 TPD (700 Bags)
Power requirement/hour	:	141 Units
Power consumption/year	:	343680 Units
Power consumption/year (Rupees in lakhs)	:	15.47
B. If the factory runs by Bio Power		
Crushing capacity of the unit	:	50 TPD (700 Bags)
Power requirement/hour	:	141 Units
Power consumption/year	:	343680 Units
Power consumption/year (Rupees in lakhs)	:	2.16
C . Net Savings		
Net Savings If the factory runs by Bio Power(A-B)	:	13.31(in Lakhs)
Net Savings/year	:	13.31 (in Lakhs)

The Clean Development Mechanism (CDM) is an arrangement letting industrialized nations with greenhouse gas reduction obligation to invest in project that reduce emissions in developing countries as substitute to more expensive emission reductions in their own countries. A vital facet of a standard CDM carbon project is that it has established that the planned reduction credits, a concept known as 'additionality'.

Global Warming Potential (GWP) of methane (CH_4) is almost 21 times that of carbon dioxide. As per the Kyoto Protocol treaty, made under the United Nations Framework Convention on Climate Change (UNFCCC) in the year 2005, industrialized countries decided to reduce their collective emissions of greenhouse gases by 5.2% compared to the year 1990. To achieve this target an arrangement viz., Clean Development Mechanism (CDM) was made to allow industrialized countries with a greenhouse gas reduction obligation to invest in emission reducing assignments in developing countries as a substitute to what is habitually considered more pricey emission lessening in their own countries.

A developed country may take up a CDM project to reduce green house gas emission in a developing country, where the cost of GHG reduction project activities is usually much lower. As of this attempt, carbon credit will be earned by the developed country, and a developing country will get the capital and clean technology to implement the project. Carbon credits are calculated in units of certified emission reductions (CERs). Each CER is equivalent to one tonne of carbon dioxide reduction.

Revenue from CER can form part of projects annual cash inflow, equity or debt. Combustion of one ton of CH_4 produces 2.75 ton of CO_2, therefore, the capture and combustion of one ton of CH_4 emissions yields a GWP benefit of at least 18.25 ton of CO_2 equivalent (5 US $ per tonne of CO_2 traded). If the captured CH_4 is used as energy source (on-site or delivered into a pipeline) the full 21 ton of GHG reductions can be claimed.

Thus, methane recovery from sago effluent serves good, both in terms of reduction in power consumption sourced from fossil fuels and reduction in global warming potential.

POLICY ISSUES AND CONCLUSION

Biogas generation from effluent has played a foremost role to change the mindset of factory owners to think that investment in pollution control is no longer unproductive and economical waste. The flip-side is the negative externalities to be observed in terms of the negative impact of effluents of sago factories on its nearby environment, which is slowly turning the sago factories from medium polluting category to high polluting category.

Not only biogas but ethanol and alcohol as byproducts can be produced from effluent of sago and starch factories. This in turn supplemented in meeting out the energy requirements in India. This should be encouraged by government. The alternative ways of utilization of byproducts should also be found out. This will encourage the factory owners to adopt the comprehensive treatment of effluents, which may reduce the negative externalities posed by sago factories.

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