



Faculty of Resource Science and Technology

**SYSTEMATIC TREATMENT OF SAGO EFFLUENT BASED ON
COMPLETELY MIXED ACTIVATED SLUDGE (CMAS) SYSTEM**

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Systematic Treatment of Sago Effluent Based on Completely Mixed Activated Sludge (CMAS) system

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ABSTRACT

The processing of sago starch produces high amount of sago effluent that could potentially contribute to the pollution of the environment. This study was conducted to observe the effectiveness of the sago effluent treatment based on Completely Mixed Activated Sludge (CMAS) system. Single and double inoculums were used in this study for 10 days. In the aeration tank, the COD level was reduced to 30.44% or 2449mg/L at day 10 for the single inoculums and 43.25% or 2431mg/L for double inoculums. The TSS produced in single inoculum was 61.58% or 1653 mg/L and in double inoculum was 54.11% or 1306 mg/L, respectively. In sedimentation tank, single inoculum treatment could reduce 42.85 % or 2449 mg/L COD meanwhile double inoculum could reduce 43.25% or 2405 mg/L COD. TSS produced in single and double inoculum were 26.62% (783 mg/L) and 15.50% (858 mg/L), respectively. The use of double inoculum for this study is better but the percentage of COD reduction is still low and not much different from single inoculum.

Keyword: Sago effluent, Completely Mixed Activated Sludge (CMAS) system, aeration treatment, sedimentation treatment.

ABSTRAK

Pemrosesan tepung sago menghasilkan banyak effluen sago yang berpotensi besar untuk menyumbang kepada pencemaran alam sekitar. Kajian dijalankan untuk mengkaji keberkesanan sistem 'completely mixed activated sludge (CMAS)' dalam rawatan effluent sago. Inokulum tunggal dan berganda digunakan dalam kajian selama 10 hari. Dalam tangki pengudaraan, tahap COD telah dikurangkan sebanyak 30.44% atau 2449 mg/L untuk inokulum tunggal dan 43.25% atau 2431 mg/L untuk inokulum berganda. TSS yang terhasil dalam inokulum tunggal ialah 61.58% atau 1653mg/L dan dalam inokulum berganda adalah 54.11% atau 1306 mg/L. Dalam tangki pemendakan, inokulum tunggal dapat mengurangkan COD sebanyak 42.85% atau 2449mg/L manakala inokulum berganda dapat mengurangkan COD sebanyak 43.25% atau 2405mg/L. TSS terhasil dalam inokulum tunggal dan berganda adalah 26.62% (783mg/L) dan 15.50% (858mg/L). Penggunaan inokulum berganda dalam kajian ini adalah lebih baik tetapi peratusan pengurangan COD adalah masih rendah.

Kata kunci: Effluen sago, sistem 'Completely Mixed Activated Sludge (CMAS), rawatan pengudaraan, rawatan pemendakan.

CHAPTER 1

INTRODUCTION

Completely mixed activated sludge (CMAS) system is a technology for treating wastewater and wastes either in domestic or in industries. This system uses an approach of using microorganism in treating wastewater in which the organic material is degraded as food. According to Cherimisinoff (1994), CMAS was successfully implemented for the treatment of industrial effluent because of its resistance to shock loadings and space utilization.

Bujang *et al* (1996) stated 20 liters of wastewater is created for every 1kg of sago starch produced. Consumption of 600 logs of sago generates 396.7 liters of wastewater containing 7.1 tons of total solid per daily operation. Furthermore, the waste products are discarded directly into the nearby river without any treatment. Although by now the effect of this is yet to be severe, but in the future it could cause serious effect to the environment and most importantly, it might endanger the ecosystem. This is due to the present of the insoluble fibers and high concentration of suspended solid in the effluent (Chew and Shim, 1993). So, it is necessary to treat the wastewater for safe discharge to ensure a save standard limit of recycling wastewater for sustainable water resource management.

The application of CMAS system had being used effective in starch based industries such as in paper industry reported by Hynninen and Ingman (1998). The system also might work effective in treating sago effluent produced by local factories seem that there is lack of wastewater treatment done. For the large volume of sago effluent produced everyday, the effectiveness of CMAS system is studied in this project as according to Cherimisinoff (1994), CMAS is resistance to shock loadings and space utilization.

The parameters such as Chemical Oxygen Demand (COD) and total suspended solid (TSS) of the effluent were studied. This is to see how effective the CMAS system used in treating sago effluent. In this study, sago effluent obtained from Nitsei Sago Mill Sdn. Bhd in Mukah was used for analysis.

In this study, the comparison of the CMAS system using single inoculums and double inoculums was used. This is to achieve the objectives of:

1. Maximizing the performance of CMAS system.
2. To evaluate the efficiency of the CMAS system in treating sago effluent
3. To minimize the contamination of sago effluent before discharging to the river.

CHAPTER 2

LITERATURE REVIEW

2.1 Completely Mixed Activated Sludge (CMAS) System

Completely mixed activated sludge (CMAS) system is one of the aerobic treatments of wastewater that using bacteria and other microorganism as the engines of wastewater treatment plan. The activated sludge is the mixture of aerobic microorganisms in the tank grow and multiply, forming an active suspension of biological solids (Nathanson, 1997). These mixtures of microorganism are using the bio-degradable material of the wastewater as food to produce a high quality effluent. According to National Small Flows Clearinghouse (2003), the term 'activated' is refer to the fact that the particles teem with bacteria, fungi and protozoa that feed on the incoming wastewater that later grow and form particles that clump together as floc and settle to the bottom of the tank and leaving a clear liquid free of organic materials and suspended solids.

This activated sludge consists of complicated mixture of bacteria, protozoa and other organism. Cheremisinoff (1994) stated that generally there are 70-90 % organic and 10% inorganic matter of microorganism in activated sludge. The bacteria in activated sludge include the genera *Acinetobacter*, *Achromobacter*, *Alcaligenes*, *Arthrobacter*, *Bacillus*, *Cytophaga*, *Pseudomonas* and *Zoogloea* (Nicoll, 1988). The composition of the microorganism is however differing according to the nutrient condition, water composition and other condition of the sludge.

The CMAS system is a 'fed-batch' process. It is a continuous-flow, aerobic biological process for treatment of domestic and biodegradable industrial wastewater (Cheremisinoff,

1994). In CMAS system, the effluent and the returned sludge are mixed and applied at several point along the length and width of the basin. The primary-treated wastewater and acclimated microorganism are aerated in a tank for a sufficient aeration period. The mixture of the aeration tank is stirred and injected with large quantities of air, to provide oxygen and keep solid in suspension (National Small Flows Clearinghouse, 2003). As microorganism grow and are mixed together by the agitation of air, individual organism floc together to form an active mass of microbes.

After that the flocculent activated sludge solids are separated from the wastewater in a secondary clarifier. The clarified wastewater will flow forward for further treatment or discharge. The resulting settled solid, the activated sludge, are returned to the first tank to begin the process again. The schematic diagram of CMAS system is shown in Figure1 below.

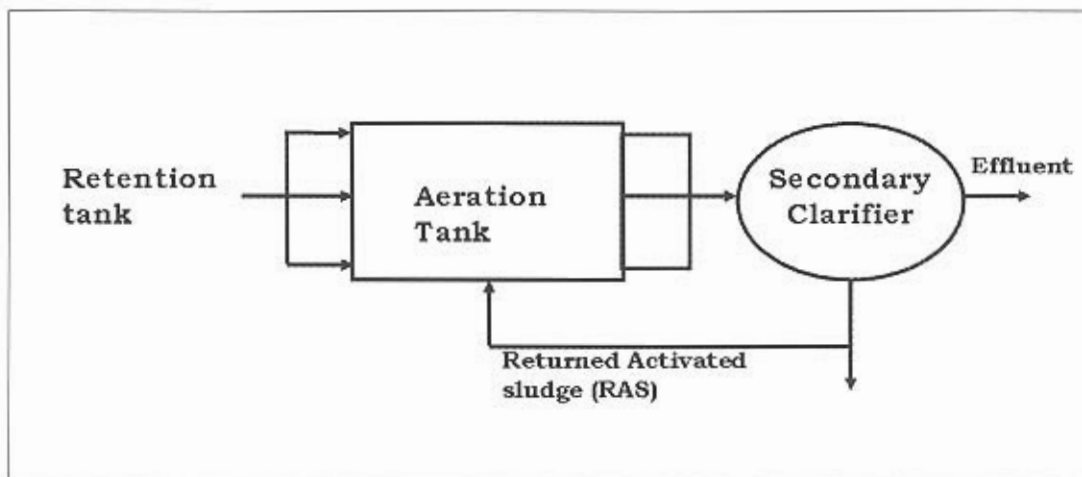


Figure 1. Schematic diagram of CMAS system (Cheremisinoff, 1994)

With the recirculation ratios in a CMAS system ranged from 50-150 percent will allows uniform oxygen demand through the aeration tank and add operational stability when

treating shock loads. Nathanson (1997) stated that a well-operated activated sludge treatment system can remove about 90% of the raw sewage Biological Oxygen Demand (BOD) and Total Suspended Solid (TSS) and sometimes the removal efficiency may be as high as 95%. The activated sludge process is widely used by large cities and communities where volumes of wastewater must be highly treated economically (Hynnimen and Igman, 1998).

2.2 Sago Industry in Malaysia

Sago palm has great potential for starch production in Malaysia. Report from Department of Statistic (2001) showed that sago starch ranks fifth highest in term of agricultural revenue after pepper, palm oil, cocoa and rubber. According to Singapore Zoological Garden Docents (2000), Sarawak small holders produce about 50,000 mt (55,000t) of air-dried sago per year for export. Sago palm is a good source of carbohydrate in which it offer 25 tons starch per ha for natural stands and between 10 tons to 25 tons starch/ha for cultivated stands (Ishizaki, 1997). Due to the economic potential of sago starch, the land Custody and Development Authority of Sarawak (PELITA) had started developed two sago plantation, one is the Dalat Sago Plantation located in the border between Oya and Igan, meanwhile another one is at the Mukah Sago Plantation located in the Mukah district.

Pejabat Daerah Mukah (2004) reported that there are about 19,406 ha land use for sago plantation in Mukah alone. There are 4 factories for sago processing industry and three other small scale industries for sago.

Sago starch was exported to Japan for the production of monosodium glutamate which requires only low quality material. Other utilization of sago starch include in producing adhesive for paper, textiles and plywood, stabilizer in pharmaceuticals (Abd Aziz, 2002), glucose, noodles caramel, sago pearls and cracker (Wagatsuma, 1994). New uses for sago include in biodegradable plastics, fuel, alcohol and ethanol (Singapore Zoological Garden Docents, 2000; Jong, 2001)

2.3 Sago Processing

The techniques for sago starch processing are quite similar to those for potato and tapioca starches. The process involves debarking, rasping, sieving, settling, washing and drying. The log section are first cut lengthwise, usually into about 8 segments that later are fed into slicer that slice the pith from the bark.

Pith from debarked logs from a trunk is chopped and the chips obtained are disintegrated. Water is added and the resulting slurry is passed through a series of centrifugal sieves to separate the coarse fibers. Fiber slurry goes to a screw press to squeeze out water that still contains large amounts of starch. The starch is often bleached with an acceptable food additive. It is purified in a nozzle separator, dewatered in a basket centrifuge or a rotary vacuum filter and then dried in hot air in a flash drier, producing a product with a moisture content of 12-14%. Figure 1 shows sago starch extraction process.

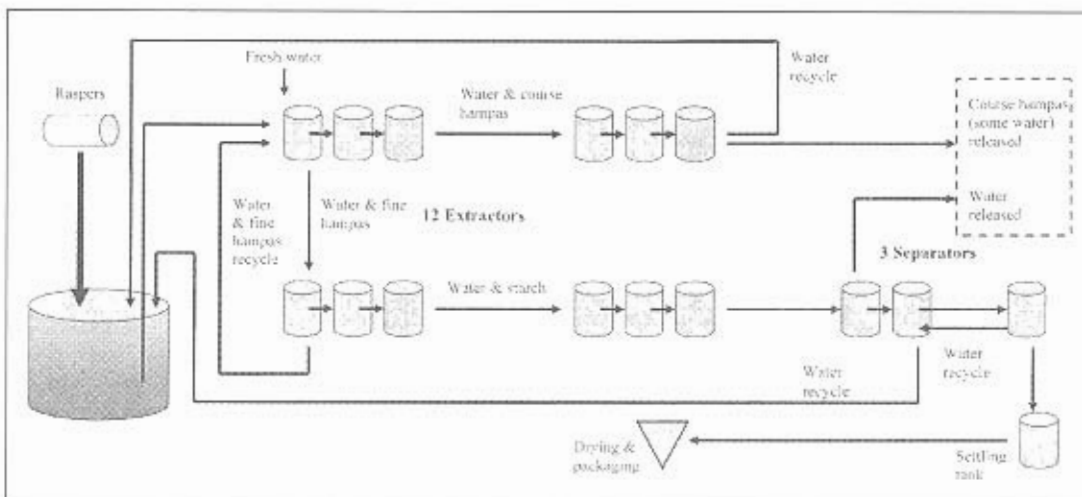


Figure 2.

Flow diagram of sago processing and production of sago effluent at Nitsei Sago Mill, Mukah (Bujang and Yusop, 2004)

2.4 Waste product of Sago Starch Processing

There are 3 waste products being produced from the processing process of sago. Those wastes are the bark, waste pith residue or hampas and wastewater. The woody component of sago logs are usually disposed into the river and may take several years to degrade (Bujang, 1996) or burned on site or used as platforms in the village.

Hampas is the fibrous waste that contains a substantial amount of bount starch and normally is discharged directly into the river without any treatment. Regarding to this matter, there are several studies that have been made for utilizing sago hampas. Some of the utilization of sago hampas is used as feed (Rizal *et al.*, 1996) and agricultural growth media (Bintoro, 1996). A study done by Shim (1992) shown that hampas can be utilized by microfungi.

According to Bujang and Yusop (2005), at the consumption rate of 600 standard (1.2m) logs/day the mill generated 5 liters/sec (18 tons/h) and 0.5 liters/sec (1.8 tons/h) of wastewater from the final effluent and the decanter, respectively. Operating at 12hrs/day, approximately 237.6 tons of wastewater containing 7.1 tons of total solids or hampas (at 3% dry matter) is generated everyday from the processing of the 600 logs. Each log would produce 396.7 liters of wastewater containing 11.9 kg of solids (average weight of log at 130kg). Thus, in a week, more than 1426 tons of wastewater (approximately 43 tons of total solids) would have been produced (2004). If a decanter is used to improve the starch quality by quickly separating the starch from the water in the pulp produced in the disintegrator (rasp), about 0.5 liters/sec (1.8 m³/hr) or more concentrated liquid effluent will also be produced. This effluent usually discharged into the river and it could cause pollution problem to the nearby river.

Sago starch effluent contains high concentration of suspended solid. Because of this, sago starch industrial units suffer from inadequate treatment and disposal of sago wastewater.

The wastewater from sago processing was acidic, high in organic load and low in nutrient. Although the effect of the pollution in the river is not severe yet, but in the future it could cause serious problem as there will be more waste to be discharge directly. This effluent contains high amount of solid (vascular bundles and fibres), some starch and is acidic (approx. pH 4). It has been shown that filtration is a very significant initial step in the treatment of sago effluent (Bujang *et al.* 2004). This, coupled with aeration managed to eliminate foul smell from the effluent, an important issue in any effluent treatment (Bujang *et al.* 2005). Typically, the COD content of crude sago effluent is between 2,600-11,000mg/L (Chew and Shim, 1993), but this can be substantially reduced to just over 1,000mg/L once filtered (Bujang *et al.*, 2004).

CHAPTER 3

MATERIALS AND METHODS

3.1 Sago effluent

Sample of sago effluent was obtained from Nitsei Sago Mill Sdn Bhd located in Mukah. Sago effluent was filtered using 710 μm mesh size filter to separate sago hampas. The sample was stored at cold room 4°C prior to use.

3.2 Microbial amendment

The commercially available Bak-Wira MP300 supplied by Accot Sdn Bhd was used in the study. Bak- Wira MP300 comprises of class I bacteria mainly bacillus strains and specific enzyme for their accelerated ability to degrade high level biodegradation contaminants such as sulfur containing compounds. Also, Bak- Wira MP300 is a live synergistic blend of all natural, and contains facultative anaerobes which can degrade with or without oxygen. According to Accot (2000), Bak- Wira MP300 is a highly specialized combination of bacterial cultures specifically selected and adapted to degrade a wide range of organic wastes, and it is proven to be effective to overcome a variety of problems such as periods of high influent loading (Bujang and Yusop, 2005).

3.3 Inoculums

The seed sludge for CMAS system was procured by treating 300mg/L Bak- Wira MP300 in 1 liter of filtered sago effluent for 2 hours to produce the slurry of Bak- Wira MP300. This is important to produce start-up activated sludge for CMAS system. Before mixing with microbial, the filtered sago effluent is pH adjusted at range of 6.5 to 7.5. This was because aerobic and facultative microbes have an optimum growth in the range of 6.5 -7.5. The growth of the microbial is influenced by the condition of the effluent (Bujang *et al*, 2004). The mixture was then aerated using electric air pump.

3.4 Treatment of filtered sago effluent based on CMAS system

3.4.1 Treatment of sago effluent with single inoculums

Two PVC tanks was used for the treatment and labeled as Tank 1a for aeration tank and Tank 1b for sedimentation. During sedimentation, the effluent was left in the tank for one day without aeration. For the pretreatment, 1L inoculum of Bak-Wira MP300 was added to 9L of pH adjusted sago effluent in Tank 1a. The treatment system is shown in Figure 2 below.

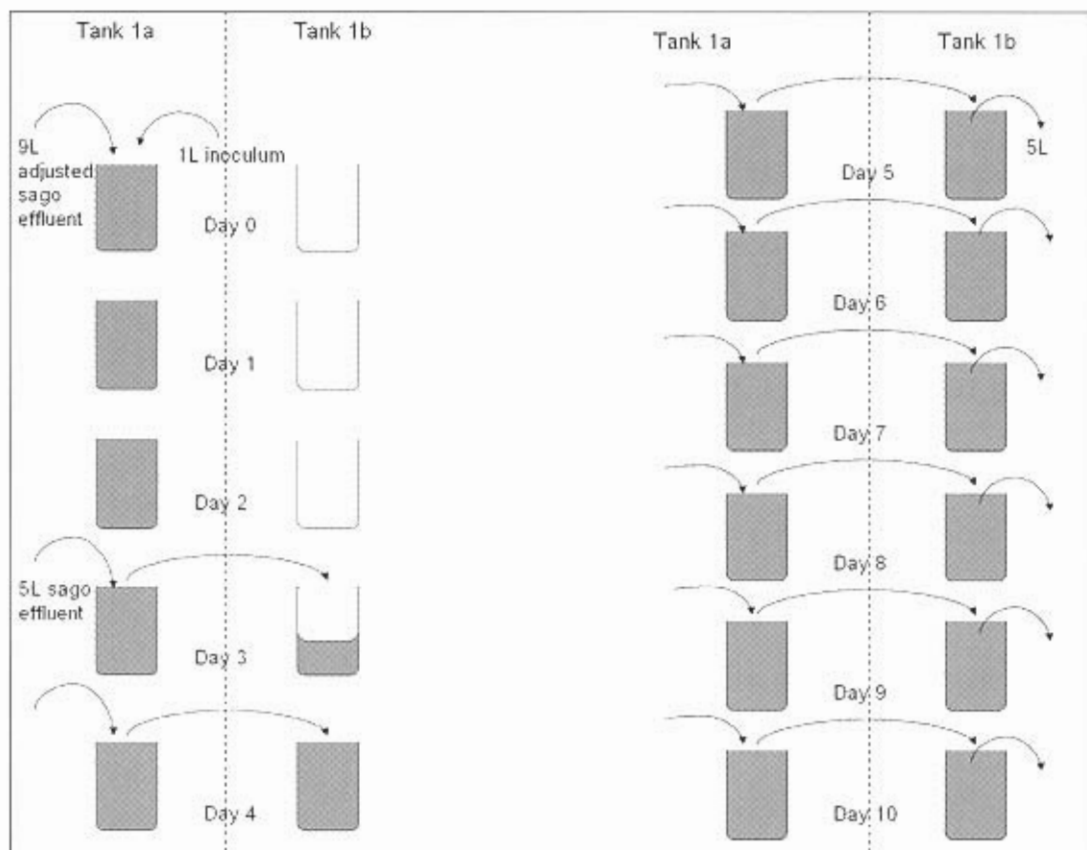


Figure 3. CMAS system for single inoculum treatment

The treatment was run at room temperature. 9 L sago effluent was adjusted to pH 7 and mixed with 1L inoculum in Tank 1a and was left aerated for 3 days. At the Day 3, 5 liters of mixed liquor in Tank 1a was transferred to the sedimentation tank or Tank 1b. New filtered sago effluent then was added to Tank 1a. The same process occurred at Day 4. During day 5, 5 liters of the effluent at Tank 1b was discharge. The same process was repeated until Day 10. Sampling was done by taking 250 ml from the aeration tank and sedimentation tank effluents.

3.4.2 Treatment of sago effluent with double inoculums

Two tanks being used, labeled Tank 2a for aeration and Tank 2b for sedimentation. The same process for the treatment with single inoculum was being applied for the first 4 days. On the Day 5, 5L of the mixed liquor of Tank 2a was transferred to Tank 2b for sedimentation. Second inoculum was added to Tank 2a together with new pH adjusted sago effluent 4L. The old mixture of Tank 1 also was being adjusted to pH 7. Then, the mixed liquor was being aerated until Day 8. The Tank 2a effluent was transferred to Tank 2b. Another 5 L of new sago effluent was added to Tank 2a and left aerated. The cycle continued until Day 10 respectively. 250 ml of the aeration and sedimentation tanks effluents was taken for sampling purposes. Figure 3 below show the illustrative of CMAS system using double inoculum.

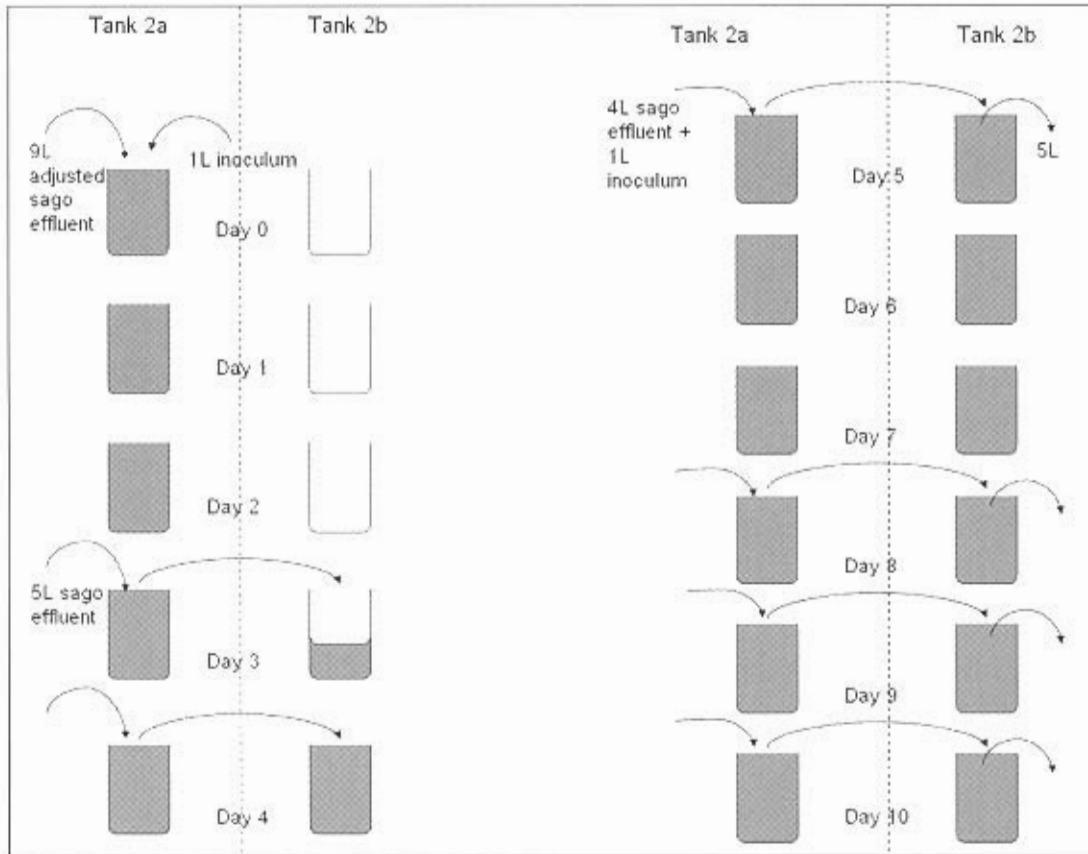


Figure 4. CMAS system for double inoculum treatment

3.5 Parameter analysis

3.5.1 Total Suspended Solid (TSS)

TSS analysis was performed as a measurement of concentration of microorganism in the liquor. The procedure for TSS analysis was done by using Standard Method (APHA 1995). 50 mL of each sample were centrifuged at 6000 rpm for 10 minutes at 4°C. Then, the supernatant was taken for filtration by using Whatman Nylon membrane filters 0.45 µm. The solid content of the centrifuge tube and the membrane filter were then dried in the oven, cooled in a dessiccator to balance temperature and weighted until constant weight was achieved. The weight of the dried suspended solid was done by subtracting the weight of the dried solid in the medium with the empty filter paper and empty centrifuge tube. The TSS data was calculated by using formula below.

$$\text{mg total suspended solid/L: } \frac{\text{total weight of dried residue, mg} \times 1000}{\text{Sample volume, ml}}$$

3.5.2 Chemical Oxygen Demand (COD)

The supernatant from the filtration was taken prior for the use in chemical oxygen demand (COD) analysis. Chemical oxygen demand (COD) of wastewater or polluted water is a measure of the oxygen equivalent of organic matter susceptible to oxidation by strong oxidizing chemicals. COD was analyzed based on the Standard Method (APHA 1995). For this study purposes, COD Digestion Reagent Vials for low range 0-150 mg/L of HACH kit was used to perform COD analysis. The filtered sample from TSS analysis was used and subjected to suitable dilution factor. Then, 2 mL of the sample was added to the HACH vial.

Another HACH vial was added with 2 mL of deionized water as a blank. The vials were capped tightly. After that, the vials were inverted several times to mix and then were placed in the preheated digester. The vials were heated for 2 hours. Later, each vial was inverted several times while still warm and was placed into a rack to let it cool to room temperature. Finally, colorimetric determination is being made.