MANAGEMENT OF PADDY SOAKING WATER: AS A SOURCE FOR ENRICHED COMPOST MAKING

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Abstract

The effluents discharged from rice mills do not contain toxic compounds, but continuous discharge in to soil or surrounding water bodies cause adverse environmental effects. Hence, the aim of the research was selected as management of paddy soaking water with its composition of nutrients as source for preparation of enriched compost and also is useful for the control of wastewater pollution and make safe the environment with effective usage. The characteristics of the effluent generated from cold soaking were acidic pH of 4.0 with concentration of nitrogen as 98 mg/l, phosphorous (91mg/l), potassium (98 mg/l), and reducing sugar (76 mg/l) and high concentration of COD (2760 mg/l), total dissolved solid (2800 mg/l) and electrical conductivity of 6mS/cm. Wastewater from the paddy soaking was then used as a potential source to an anaerobic composting. The digester with organic solid waste of 5 kg was mixed with 30 lit of rice mill effluent and other with 30 lit of water as control. The experiment was conducted in complete randomize design with three replicates. The use of rice mill wastewater significantly increased the available nitrogen, phosphorous and potassium after completion of 42nd days. Chemical analysis of digestate revealed that nutrition profile for anaerobic compost making of paddy soak water with waste was better than that of water. The C/N ratio decreases with days of composting but the reduction rate was high in paddy soak water than the water treated. Therefore, the rice mill wastewater is useful for compost making in anaerobic condition with the production of enriched compost.

Keywords: Paddy soak water**, W**aste, Anaerobic digestion, Compost

1. Introduction

The growth of the world's population, increasing urbanization, rising standards of living and rapid development in technology have all contributed to an increase in both the amount and variety of wastes generated by industrial, domestic and other activities. Wastewater coming from different industrial operations contains high concentration of organic and inorganic substances causing significant polluting phenomena. Rice is the stable diet in Sri Lanka, is produced from processing paddy in various ways (Hettiarachchi *et al*., 2001). Parboiled process is practiced in different methods. A significant amount of water is consumed in soaking process. The effluents of paddy mills practicing parboiling process mainly consist of wastewater generated from soaking operation. In most of the rice mills in Sri Lanka this effluent is discharged into inland surfaces or surrounding water bodies without any treatment (Ariyaratna *et al.*, 2007 and Environment and Management Lanka (Pvt) Ltd., 1999). The continuous discharge of this effluent into the environment has become an environmental concern.

The effluent discharge from rice mills do not contain toxic compounds or pathogenic bacteria (Ramalingam and Raj, 1995), but the continuous discharge into soil or surrounding water bodies can cause adverse environmental effect. The stagnant water emits off-odours and these off-odours can be carried away by wind as well. Off-odours during soaking can be developed due to fermentative changes. Impact on public health due to soak water discharges into land and water bodies is another issue. Environmental pollution resulting from rice mill wastewater has become a huge problem in Sri Lanka (Environment and Management Lanka (Pvt). Ltd, 1999). The total number of rice mills in Sri Lanka is around 7000. About 23% of these rice mills practice parboiling process (Karunaratne, 2010). Environment and Management Lanka (Pvt). Ltd, (1999) had shown that parboiling mills discharge up to 60.4 m^3 of wastewater for every 8 tons of paddy soaked. The value of chemical oxygen demand (COD) in parboiled paddy effluent varied in a wide range from 2578 mg/l to 6480 mg/l (Subramaniam and Daksinamurthy, 1977). The pollutant load in terms of COD can be about 3.91×10^5 g/day for 8 ton/day capacity rice mill (Karunaratne, 2010).

Solid waste accumulation is other main problem in urban areas of the Sri Lanka and this is due to absence of proper solid waste management. At present daily per capita waste generation is 0.65-0.85 kg/day in Sri Lanka (Wijesekara, 2010). Waste management is the disposal of waste materials, usually ones produced by human activity, in an effort to reduce their effect on human health or local aesthetics or amenity. Hence the objective was selected as management of paddy soaking water and organic solid wastes together to produce enrich compost. Also the specific objectives was selected as evaluation of the constituents of fresh effluent of paddy soaking water with the soaking time and analysis of an anaerobic decomposed waste material with the application of paddy soaking water.

2. Materials and methods

2.1 Wastewater collection

The paddy soaking water was collected from Leela rice mill at Maruthanarmadam and Saraswathy rice mill at Kokkuvil. The paddy variety of *Aaddakari* was used in both rice mills. Also the laboratory test was carried out with 2 kg of *Aaddakari* paddy variety and it was soaked in a 3 lit of water as soaking practice in the mills. The soaking water was collected from the same tank continuously for four days from both mills and laboratory in a clean air tight screw cap bottle for analysis. The analysis was carried out in every day up to 4 days of soaking.

2.2 Collection of waste

Organic waste is most suitable for composting and it was collected from different locations. There are no any special separation methods for generated waste. The waste load, obtained for the research work was separated manually to obtain full organic fraction for composting. The total of 5 kg organic fraction was weighted randomly from the collecting point for each bucket.

2.3 Design of the compost digester

Compost digester was designed with anaerobic technology. The materials of 50 lit plastic bucket and black hard polythene was used to design the anaerobic compost digester. To ensure the air tight condition black colour polythene and air tight paste were used to cover the materials to prevent the transportation of air from inside to outside and vice versa.

2.4 Treatment schedule and sample collection

In the anaerobic treatment every 50 lit bucket of compost digester was filled with 5 kg of waste and 30 lit of paddy soaking water. Meantime control treatment was schedule with 5 kg of waste with 30 lit of water. The samples of compost were collected at uniform weekly interval from the anaerobic digester namely as 14, 21, 28, 35 and 42 days after treatment respectively. The experiment was conducted in complete randomized design with three replicates. Samples were taken at different location of the digester and were mixed thoroughly and the representative sample was taken from the composite sample. After that it was spread under at an air dried condition. Finally the collected samples were ground by grinder to break down the materials.

2.5 Method of chemical analysis

The paddy soaking water was analyzed for its pH, total nitrogen, phosphorous, potassium Total Dissolved Solids (TDS), Electrical Conductivity (EC), potassium, reducing sugar and COD.

Also digestate was analyzed for total nitrogen, available nitrogen, total carbon, available phosphorous, and available potassium.

3. Result and discussion

Effluents of paddy soaking water enrich with some nutrient and incorporation of this wastewater promotes the population of the microorganism which increases the digestion process (Karunaratne, 2011). General observation was made in rice mills of Jaffna in Saraswathi mill at Kokkuvil and Leela rice mill at Maruthanarmadam. Both mills run for 25 days per month. The capacity of soaking tank is 6 m^2 in both rice mills and constructed by cement. The number of tank present in Saraswathi mill and Leela rice mill is four and three, respectively Everyday around 3000 kg of parboiled paddy was produced in each mill. This practice produces around 3500 liters of wastewater by soaking operation in rice mills in a production day. Usually soaking of paddy is up to four days in a soaking tank in both rice mills. Even though the recommendation of changing of water is every twelve hours, the mills are not changing the soaked water everyday. It was depend on the availability of labour.

3.1 Composition of paddy soak water

Table 1 shows the composition of soak water from two different private mills and laboratory test. The values of EC, TDS, phosphorous, total nitrogen, reducing sugar and potassium were raised in paddy soaking water compared to groundwater used for soaking and the value of pH of the soaked water decreased. The components of soaked water of laboratory values were comparatively lower than other two mills since the amount of paddy used for test was small. There were significant different found in measured parameters between the treatment of soaking days in dunnett mean separation but there was no significant different found between the different mills in soaking operation at α is equal to 0.05.

Table 1: Composition of paddy soaking water at the end of the fourth day

Components	*Groundwater Used*	*Laboratory test*	*Saraswathy mill*	*Leela rice mill*
pH	*6.78*	*4.92*	*3.71*	*3.99*
EC (mS/cm)	*1.012*	*5.145*	*6.09*	*5.72*
TDS (mg/l)	*496*	*2385*	*2630*	*2878*
Phosphorous (mg/l)	*0.114*	*87.412*	*91.845*	*86.43*
Total nitrogen (mg/l)	*6*	*42*	*84*	*98*
Reducing sugar (mg/l)	*1.73*	*36.5*	*58.3*	*68.2*
Potassium (mg/l)	*9*	*58.2*	*78*	*98.3*

Bandyopadhyay and Roy, 1992 stated that prolonged soaking at ambient temperature leads to the heightening of enzymic activity, fermentation of grain as well as of the organic impurities mixed with the grain and subsequent pollution of the soak water leads to decrease the pH According to Takahiro *et al*. (2011) relatively higher population of aerobic bacteria, staphylococci, lactic acid bacteria and yeast were reported in soaking water of cold soaking. The acidic condition of paddy soak water discharge in to the soil leads to increase the acidity of soil and decrease soil alkalinity. So treatment of soak water is important before discharge to environment. Maria *et al.*, 2006 stated that cyanobacteria stirred batch reactor was used to neutralize the pH. In their studies the pH of culture medium increased significantly throughout the cultivation period. Przytocka-Jusiak *et al.*, 1977 reported that the heterotrophic growth of the cyanobacteria was usually accompanied by change in pH.

During the period of soaking, EC of soak water varies between the range of 1- 6 mS/cm. TDS expressed the inorganic salts and small amount of organic matter that dissolve in water. Pillaiyar *et al*., 1980 stated that leach out of salts and nutrients from paddy grain and husk increases with soaking time which leads to increase the TDS. For the removal of EC of paddy soak water, Manogari *et al*., 2008 reported that biodegradation involving of microorganism *pseudomonas sp* immobilized cells reduce the EC and salinity of soak water. Groundwater is used for soaking that may affect the parboiled paddy quality (Gunathilake, 2012) and at the same time it affects the nutrition leachate. The result was supported by the study of Poritosh *et al*., 2011in which total sugars (reducing sugar and sucrose) also increases with soaking time.

The total nitrogen increases with soaking time in all three treatments. During the period of soaking, total nitrogen of soak water varies between the ranges of 14-98 mg/l. Poritosh *et al*., 2011 stated that total nitrogen expressed the leach out of amino acid from the paddy. Also the phosphorous and potassium content were increases with soaking time. During the period of soaking, phosphorous and potassium content of soak water varies between the range of 15-91 mg/l and 18-98 mg/l respectively. Since the paddy soak water enrich with the nutrients it could be used as a source for media and incorporation of this wastewater promotes the population of the microorganism which increases the digestion process of waste

The table 2 shows the COD and the relationship between the C/N and N/P ratio of the rice mill effluent with measured COD value. The observed variation in COD and total N were attributed with variation in the soaking time. Subramaniam and Daksinamurthy, 1977 stated that the length and temperature of the rice soaking operation allowed for different levels of protein and soluble carbohydrates losses to wastewater, reflected in compositional variations of the effluent. The C/N ratio was higher than that required for development of the microorganisms (C/N=20) in soaking water. Hence, soaked water can be considered as potential source of nitrogen and organic matter for the production of single cell protein to micro organisms as stated by Xing *et al.*, 2000.

Table 2: C/N and N/P ratio of rice mill soaked water

Days of soaking	*COD*	*N*	*C/N*	*P*	*N/P*

	(mg/l)	*(mg/l)*		*(mg/l)*	
1	*1120*	*28*	*40*	*20.862*	*1.342*
2	*1600*	*56*	*28.57*	*54.906*	*1.019*
3	*2240*	*84*	*26.66*	*69.402*	*1.210*
4	*2597*	*98*	*26.5*	*86.430*	*1.134*

The COD removal indicates by the removal of organic matter from the rice mill wastewater to reduce the water pollution in water source and safe for the environment. Biological treatment methods such as aerobic, anaerobic and physical treatment methods such as coagulation and adsorption were investigated. According to the literature the removal of COD and organic matter from the parboiled rice effluent is by several ways. Queiroz *et al.*, 2006 stated that the kinetics of the removal of nitrogen and organic matter from parboiled rice effluent by cyanobacteria in a stirred batch reactor is efficient method to removal by 82% of COD and 73% of total N. In another research by Manogari *et al.*, 2008 the bio degradation of rice mill effluent by immobilized *pseudomonas sp* cells decrease the electrical conductivity by 82%, salinity by 82%, TDS by 81%, turbidity by 48% and COD by 86% .Treatment of rice mill wastewater by electro coagulation used with Aluminium electrodes remove the COD, turbidity and suspended solid (Shrivastava and Soni, 2011).

3.2 Component of digestate

Digestate is the solid fraction, getting from the digester during the completion of digestion process. In the anaerobic digestion process digester produces both solid and liquid as by products, which could be utilized as either fertilizer or soil amendments. Digestate is a valuable source of available plant nutrients, particularly nitrogen, phosphorous and potassium.

Table3: Concentration of nutrients in treated digester

Nutrients / Days	*Phosphorous*	*Potassium*	*Available nitrogen*	*Total nitrogen*	*Total carbon*
14	*144.79^{d} ± 24.9*	*146.17^{e}±24.0*	*8.4^{e} ± 1.66*	*1.449^{a} ± 0.04*	*36.335^{a}± 0.4*
21	*161.31^{cd} ± 37.5*	*171.33^{d}±21.5*	*9.8^{d}± 1.66*	*1.387^{b}± 0.05*	*33.618^{b}± 1.3*
28	*172.67^{bc} ± 33.4*	*193.83^{c}±16.3*	*11.2^{c}± 2.38-*	*1.329^{c}± 0.05*	*31.852^{c}± 1.3*
35	*187.95^{ab} ± 28.5*	*207.50^{b}±19.4*	*13.3^{b}± 2.38*	*1.248^{d}± 0.08*	*29.437^{d}± 2.6*
42	*196.32^{a} ± 35.3*	*220.50^{a}±23.4*	*15.75^{a}± 3.51*	*1.173^{e}± 0.09*	*26.894^{e}± 3.4*

The same letters shows not significant among the data

The table 3 shows the variation of concentration of phosphorous, potassium, available nitrogen, total nitrogen and total carbon in treated anaerobic digester with paddy soaking water and water with days after treatment. Carbon content decreases with time by the utilization of carbon by microbes for their energy need and microbial activity (Huang *et al.*, 2004). The significant different was found between the treatment and days after collection of digestate in LSD mean separation at α = 0.05.

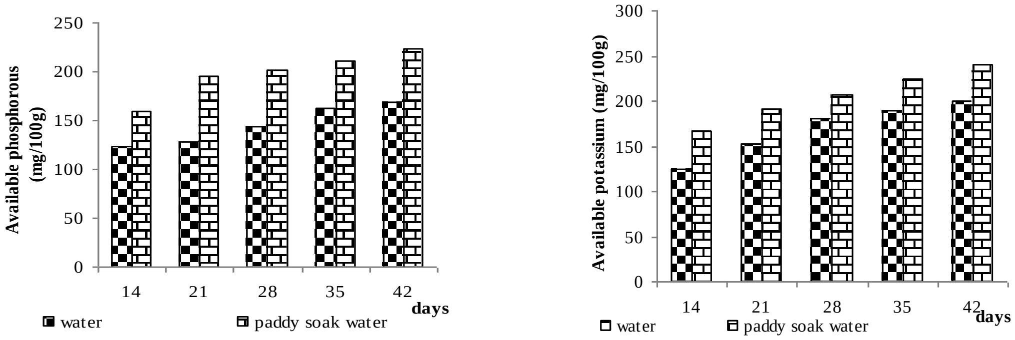

Figure 1: Changes of phosphorous and potassium in an anaerobic situation

The figure 1 shows the relationship between changes of phospharous (mg/100 g) and potassium (mg/100g) with digestion duration. Both the phospharous and potassium increases with time in both process of anaerobic digestion with paddy soaking water and water. But the increasing rate was high in organic waste with paddy soaking water than water treated digestate which was due to high rate of microbial activity.

Table 4: Nutrient profile of digestate

Components	*Phosphorous (mg/100g)*	*Potassium (mg/100g)*	*Available Nitrogen (mg/100g)*	*Total Carbon (g/100g)*	*Total Nitrogen (g/100g)*	*C/N ratio*
Waste with water	*145[b]*	*169 [b]*	*9.66 [b]*	*33.26 [a]*	*1.37a[b]*	*23.8 [a]*
Waste with paddy soaking water	*199 [a]*	*206 [a]*	*13.72a[b]*	*29.99 [b]*	*1.27 [b]*	*21 [b]*

The same letters shows not significant among the data

Table 4 shows the phosphorous, potassium and available nitrogen increases with time of composting in both process of anaerobic digestion with paddy soaking water and water. After 42[nd] day the mean of 199 mg of phosphorous were observed in 100 g digestate in waste treated with paddy soaked water whereas water treated digestate showed 145 mg phosphorous. The results of available nitrogen and potassium showed that 13.72 mg and 206 mg respectively in 100 g of digestate in waste treated with paddy soaked water. But the results of water treated one showed 9.66 mg and 169 mg for available nitrogen and potassium respectively

Microbes increase the breakdown of inorganic phosphorous as organic form and mineralization of phosphorous also increase. There was no leaching loss in anaerobic digester so that leads to increase the phosphorous content. Available nitrogen is in the form of NH_4^+ and NO_3^-. Plants take up the nitrogen in the available form. Complex organic nitrogen compounds converted in to simple inorganic compounds by microbes which lead to increase the available nitrogen.

Reduction of C/N ratio favours the mineralization. Increasing rate was mainly by NH_4^+ ions. Mineralization of ammonization and ammonification increase the ammonium ion. The ammonization produces the amino compounds from enzymic hydrolysis of protein. This amino compound was rapidly transformed by ammonification. Ammonification produces NH_4^+ ions by heterotrophs microbes.

Total carbon content and total nitrogen content decreases with composting process of both treatment of paddy soaking water with waste and water with waste. But the decreasing rate of carbon is high compared with nitrogen. The volatilization loss of nitrogen very little in an anaerobic digester. Carbon is released as heat by microbial activity. Total carbon content and total nitrogen content decreases with composting process of both treatment of paddy soaking water with waste and water with waste. But the decreasing rate of carbon is high compared with nitrogen. Due to that C:N ratio decreases from 25 to 21 in composting process.

Increasing the availability of nutrition and reduction in the C/N to the optimum level of decomposition in the waste treated with paddy soak water favors the results of anaerobic digestion than the waste treated with water. Hence treating the waste with paddy soaking water could be recommended to manage the solid and liquid waste together to have clean environment while enriching compost production.

4. Conclusion

Paddy soak water was acidic in nature and it contains high level of soluble salts and nutritions such as N (98 mg/l), P (91 mg/l) and K (98 mg/l). Paddy soak water contained high level of COD. Nutrition composition of soak water increases with soaking duration but pH reduces with soaking time and reaches to pH 4. All nutrition composition; available nitrogen, potassium, and phosphorous of treated digestate were significantly different from water treated digestate. Anaerobic composting is suitable for liquid waste with solid waste as one of the eco-friendly waste management to have clean environment.

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