Modification and Evaluation of Parboiling Wastewater Discharge System for Minimizing the Effluent Volume to Be Treated in Rice Processing

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Abstract
This study was conducted to reduce the wastewater volume to be treated in rice milling industry by modifying the existing effluent discharge system and the cleaning process. At the beginning, pH, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) levels of existing wastewater ditch were measured. Paddy cleaning section of parboiling was improved. Waste water generated from washing was directly released to irrigation purpose, and effluent of soaking tanks was collected to a ditch followed by 10 hours aeration treatment. The waste of steaming process was directly sent to ash room. The BOD, COD, and pH values of wastewater, collected in every operation of rice parboiling, were analyzed. pH values of effluents indicated considerable improvement after the treatment. After the modifications of the wastewater discharge system, the BOD and COD levels of wastewater in the ditch, used for washing and soaking showed significant reduction ($p<0.05$) compared to existed conditions, from 2150 ml/l to 389 ml/l and from 3776 ml/l to 687 ml/l, respectively. Further, wastewater used for paddy washing can directly be utilized for irrigation purposes due to lower values of BOD and COD. The levels of BOD and COD of steamed water collected in separate small ditch resulted in significantly higher levels ($p<0.05$) than other wastes. Aeration treatments applied to the ditch of soaking water had significantly reduced ($p<0.05$) these parameters below the maximum recommended limits for irrigation purpose. The study reveals that proper management of paddy cleaning process and wastewater discharge system can maintain the BOD and COD levels below to the recommended limits.

Keywords: Aeration, parboiling, waste water, COD, BOD
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Introduction

Prevention of environment pollution is one of the key issues of any industry in Sri Lanka. Rice processing is the major agro-based industry operating around seven hundred mills throughout the country in which rice is produced into both raw and parboiled forms. Production of parboiled rice involves washing, soaking, steaming and drying processes that require large amount of water specially for cleaning and soaking of the paddy. The almost same amount of this water is discharged as wastewater containing many organic materials that pollute the water. Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) are considered as main indicators of the pollution of wastewater. The pollution level of wastewater released from rice mills depends on the water usage time, paddy quality, temperature and type of soaking (Gariboldi, 1984). At present, rice millers maintain BOD and COD levels at about 310mg/L and 1100mg/L respectively by changing the water in less than 12-hour intervals in soaking tanks (Rathnayake *et al.*, 2010). Even though soaking water is changed every 12 hours, COD and BOD levels of releasing water are higher than the values set by CEA for irrigation purposes; 250mg/L of BOD and 400mg/l of COD (CEA, 1990). Therefore, sustainability of this industry relies addressing the waste streams in a productive manner.

Most of the rice mills are located in major rice cultivating areas, and they usually release wastewater to irrigation systems without being treated. According to Ariyarathne *et al.* (2007), the volume of effluent discharged per day by a rice mill with 10t of processing capacity is approximately 33,000 L which is very high volume to be treated within a day. Available effluent treatment methods developed for rice milling industry are very costly which medium and small scale rice miller could not acquire. Hence, development of technically and economically feasible effluent management method is essential to minimize the environment pollution that occurs due to wastewater discharged from rice mills. Therefore, this work was done to collect wastewater discharged from washing, soaking and steaming sections separately in order to reduce the amount of wastewater to be treated. The study further evaluated the pollution level of wastewater in each stage and required treatment level.

Materials and Methods

Modifications of exiting effluent discharge system: The study was carried out at Tesco Lanka Rice mil, Srawasthipura, Anuradhapura. Initially, water samples that are used for processing and wastewater samples discharged from the rice mill as a mixture of washing,

cleaning and steaming water were collected. Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) of these samples were measured using BOD track apparatus (Model: VELP BMS6) and COD reactor (Model: HACH DRB 200) subsequently. Then, the existing wastewater discharge system was modified so that paddy washing and steaming water could be collected separately as shown in Figure 1.
The paddy cleaning system also was updated to prevent the mixing of dust and impurities with water in the paddy soaking tanks. Water pumps were placed in the wastewater collecting ditches to remove the treated wastewater just after the treatments. An electrically operated aerator (Model: CA200/3) was fixed to the ditch where paddy soaking water was released. Wastewater released from steaming unit was collected to separate ditch and send to ash bin where ash of paddy husk removed from boiler furnace is deposited.

Testing and data collection: Paddy was properly cleaned at receiving and sent to washing/soaking tanks. Then, paddy was washed using fresh water for four hours of period. After that, wastewater was released to a separate tank and water samples were taken for analysis of BOD, COD and pH. Then, the paddy was soaked for 24 hours of period at ambient conditions using fresh water. After 12 hours of soaking period, water in the tank was replaced with fresh water. The initial pH, BOD and COD values of fresh water and wastewater used for soaking in first round were measured. Wastewater discharged from soaking tank was transferred to a ditch and analyzed for pH, COD and BOD levels initially. Thereafter, wastewater in the ditch was aerated for ten hours of period and then again pH, BOD and COD levels were measured. Finally, treated wastewater was released, and this processed was continued for next batch as well.

The soaked paddy was subjected to steaming process. During steaming, certain amount of steam was converted in to liquid form that is removed as wastewater. This wastewater is rich in nutrients that tend to high microbial growth. Eventually, this wastewater was collected to separate small tank, and a mechanism was developed to pump paddy steaming waste directly to the ash room where wastewater produced during parboiling, evaporate easily due to high temperature. Three replicates were used at each sampling time. Experiment procedure was repeated three times.

Data analysis: The experimental design was Completely Randomized Design (CRD).

Data gathered was analyzed using Analysis of Variance (ANOVA) by Statistical Analysis System. Differences between treatment means were obtained by Duncan's multiple range test at 5% significance level ($p<0.05$).

Results and Discussions

Table 1 shows the existing conditions of wastewater of the rice mill and conditions after the modifications.

As can be seen in the Table 1, the level of BOD and COD of waste water, which was collected from any step of rice parboiling process, were significantly higher ($p<0.05$) than fresh water. pH values of effluents depicted significant reduction than to fresh water because production of organic acids in waste create low

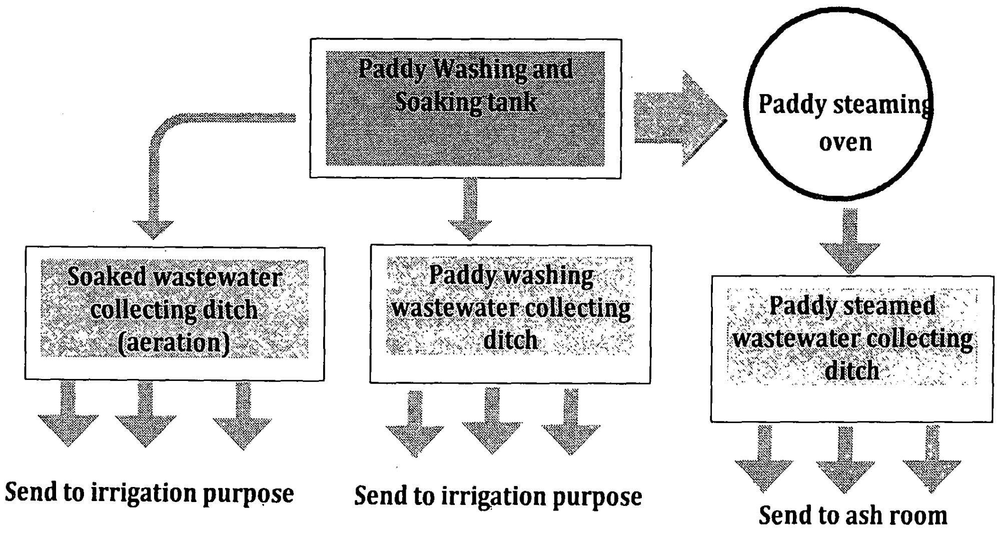

Figure 1: Modified wastewater discharge system

pH conditions (www.info.oxymen.com, 2015). After the modifications, it is obvious that BOD and COD levels of wastewater in the ditch, used for washing and soaking showed significant reduction compared to existed conditions.

Moreover, wastewater released from paddy washing can directly be utilized for irrigation purposes. According to the CEA (1990), the This proves that proper cleaning of paddy before washing and soaking and removal wastewater separately are effective in managing effluents. maximum levels of BOD and COD recommended for irrigation purposes are 250mg/l and 400mg/l respectively. However, BOD and COD level of wastewater in the ditch and released from soaking tanks were above the recommended maximum values. Therefore, this water could not be released for irrigation purpose without lowering the pollution level. The levels of BOD and COD of steamed water collected in separate small ditch showed significantly higher levels than that of other ditches. Usually, effluent released from steaming section contain higher amount of nutrients, especially carbohydrates, leaked from rice grains.

Table 2 presents the wastewater conditions of modified systems before and after the treatments. As shown in the Table 2, aeration treatments applied to the ditch where wastewater of soaking tanks was collected had significantly improved ($p<0.05$) the water quality parameters. BOD and COD levels of water samples after the aeration treatment were lower than to the water in the ditch before treatment, whereas, these values were significantly higher of second water batch than first bath. Scott and Ollis, (1995) reported that aeration of waste materials were effective in preventing the development of anaerobic conditions. However, values of BOD and COD of paddy washing water were below the maximum recommended limits that could be suitable for irrigation purpose.

Conclusion

The study revealed that collection of wastewater separately from washing, soaking and steaming sections of rice processing reduced the volume to be treated, saving time and cost of effluent management. Wastewater discharged from paddy washing could directly be released for irrigation purpose. Application of aeration treatment to soaking water at effluent ditch is effective in controlling COD and BOD levels below the recommended limits.

Table 1: water quality parameters of wastewater in existing and modified systems

Water/waste water type	**Quality parameters**					
	BOD (ml/l)		**COD (mg/l)**		**pH**	
	T1	T2	T1	T2	T1	T1
Fresh water	19[g]	22[g]	55[g]	51[g]	6.2[a]	6.5[a]
Waste water in existing ditch	2150[a]	389[d]	3776[a]	687[c]	4.5[c]	4.7[bc]
Waste water of washing tank	280[e]	193[f]	385[e]	264[f]	5.3[b]	5.1[b]
Waste water of soaking tank	562[c]	302[e]	710[c]	550[d]	4.8[bc]	5.1[b]
Steamed water	-	1162[b]	-	2311[b]	-	4.9[bc]

Values with same letter in rows and columns for a same parameter are not significantly difference ($p=0.05$) T1-Existing system, T2-Modified system

Table 2: effect of aeration treatment on quality parameters of wastewater

Water/waste water type	**Quality parameters**					
	BOD (ml/l)		**COD (mg/l)**		**pH**	
	T1	T2	T1	T2	T1	T1
Soaking water in treatment ditch(first water batch)	324[b]	188[d]	638[a]	329[c]	4.9[c]	6.2[a]
Soaking water in treatment ditch (second water batch)	508[a]	213[c]	754[a]	340[c]	4.2[d]	5.9[ab]

Values with same letter in rows and columns for a same parameter are not significantly difference ($p>0.05$) T1-Bofore treatment, T2-After treatment

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