WATER POLLUTION LOAD FROM HOUSEHOLD INDUSTRY : A CASE STUDY OF KHANOMJIN (LOCAL NOODLE) PRODUCTION

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ABSTRACT

Khanomjin (local noodle) production is categorized as household industry, according to Thailand industrial law, and requires no wastewater treatment facility. The study in Huay Nam Rin village, Chiang Mai, Thailand, during September to December, 1999, indicated that the typical producer (with 2-3 workers) generated 415.6 kg noodle/d and discharged wastewater around 4.2 m^3/d, directly to receiving water bodies. The wastewater had average COD and SS concentrations of 1,927 and 2,070 mg/l, respectively, with COD:TKN:TP ratio of 100:0.04:0.09. The unit wastewater flow and organic load were found to be 10.1 l/kg noodle produced and 19.5 g COD/kg noodle produced, respectively. Due to exceptionally high numbers of activities (23 Khanomjin producers and 2 rice cake producers) in the study area, water pollution load from household industry is quite significant. It is estimated that the producer earns profit around 26,000-64,000 Baht/mo and should be able to install individual pretreatment unit prior to discharging. Anaerobic treatment facility with at least 50% efficiency is suggested due to its simple operation and affordable cost. Village-level guideline for wastewater treatment should be issued. Incentive and social sanction are also required to encourage the pollution control in this village.

Key words: Khanomjin, rice cake, organic load, wastewater

1. INTRODUCTION

Noodle consumption in Thailand is very popular and there are various types of noodles, i.e. yellow, white in small-, medium- and large-size, green, pre-cooked, instant, etc. These products are mainly in dry packages and can be stored for a long time. They are mostly produced by medium and large factories which are required by law to install wastewater treatment facilities. However, there is one type of noodle called “Khanomjin” which must be daily produced. Khanomjin, meaning Chinese dessert, are cheap and widely consumed throughout Thailand. It can be eaten with many kinds of curry. Khanomjin is the completely cooked flour from wet process and can be stored for very short period, 1-3 d, in refrigerator. The production is usually done locally by small scale entrepreneurs in their backyards. According to Thailand industrial law, the producer are categorized as “household industry” and need not to comply with industrial wastewater effluent standard. Direct discharge of Khanomjin wastewater is therefore common while the water pollution levels varies according to numbers of manufacturers and self-purification capacity of receiving water bodies. The objectives of this study is to characterize the water pollution load from Khanomjin production and to examine the business financial situation.

2. MATERIALS AND METHODS

This study was conducted at Huay Nam Rin village, amphoe Mae Rim, which is situated approximately 20 km north of Chiang Mai, Thailand. This "Khanomjin Village", as called by locals, has 23 Khanomjin producers and 2 rice cake producers which is exceptionally high in numbers as compared to other typical village elseware. Khanomjin production has taken rooted here for several years. The products are daily transported to markets throughout Chiang Mai area. Five Khanomjin factories were selected as study areas. All wastewater analysis were conducted according to "Standard Methods" (APHA, AWWA, WPCF, 1992) at the Department of Environmental Engineering, Chiang Mai University (CMU). The study was conducted during September to December, 1999.

3. RESULTS AND DISCUSSION

The production process consists of two steps, i.e. rice cake and noodle productions. The diagram of rice cake production is shown in Fig.1. There are 2 rice cake producers in this village. One entrepreneur mainly produces for his subsequent noodle production while the other also sells rice cake to any noodle producers. Most of noodle producers use rice cake transported from other village. It can be imply that there are some villages where rice cake production are predominant.

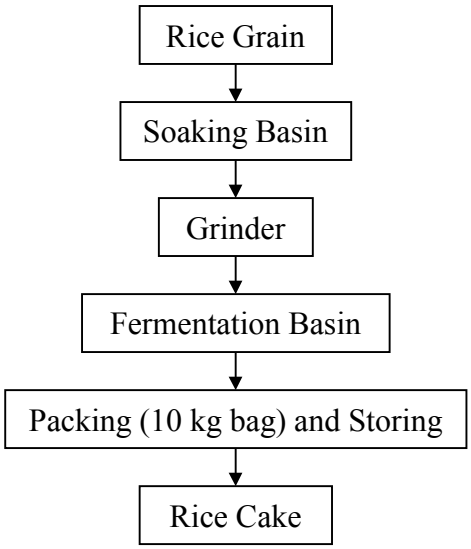

Figure 1. Rice Cake Production

According to Fig.1, the rice grains are soaked for 1 night prior to grinding into flour. The flour is mixed with water and stored for 1 day in fermentation basin. It will become the hardened cake and be packed on 10 kg plastic bags. Three days storage in plastic bags are required so that sufficient fermentation will occur. The rice cake is then ready for sale to Khanomjin producers. If storage periods are too long, i.e. 1 week or more, the noodle will turn sour or spoil. The rice cake factories employ simple machinery with 2-3 workers. The diagram of Khanomjin production is shown in Fig.2.

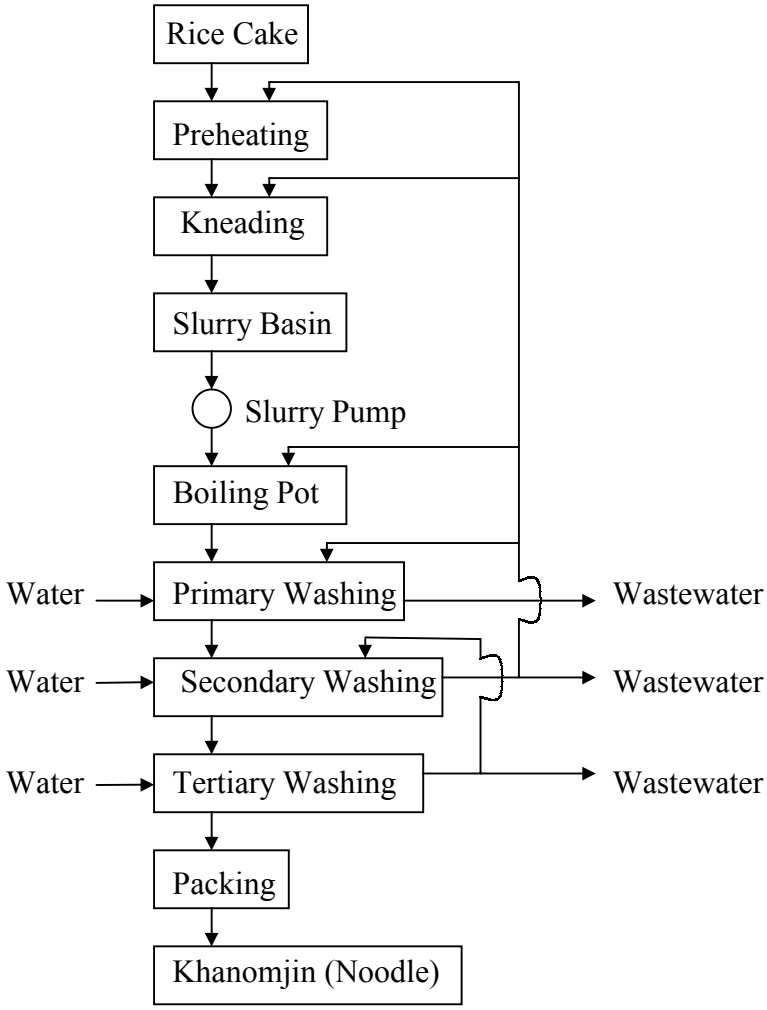

Figure 2. Khanomjin Production

The rice cake, in plastic bag, is preheated in boiling water prior to transferring to kneading machine where cake is mixed with water. After mixing, the rice slurry is filtered through hand screen and stored in slurry basin. It is then pumped through sprayhead and be splitted into small strings before dropping into boiling water. The strings will be completely cooked and washed for three times. The finished noodle is packed in 5 kg bundles. Water savings are practiced through reuses of washing water in various steps. It was found that most noodle producers use similar machinery which is made in Thailand. It can be imply that Khanomjin producers thoughout the country do the similar procedures with the same type of machine. Since this kind of noodle comes in wet type, it must be transported to market and consumers as soon as possible while long time storage may result in noodle spoiling. There is no large scale factory, at least in Chiang Mai area, who do this business. The producers, middlemen and sellers are all small entrepreneurs. The interview results showed that the numbers of workers in each factory were 2-4 persons and in some case, the owner himself joined the production. The working hour are generally from 9:00 AM to 12:00 AM. Workers were paid according to the noodle or rice cake quantities, i.e. 12-13 Baht/10kg of rice cake used (40 Baht = 1 US dollar), 0.5-1.0 Baht/kg noodle packed for those who do packing. The investigations on water consumption were conducted by meter installation on the supply line. The water sources are mostly shallow wells, equipped with home pumps (pumps and pressure tanks with automatic switches). The water balance is presented in Table 1.

Table 1. Water Balances of Khanomjin Production

Factory	Observation Day	Rice Cake Used kg	Noodle Produced kg	Water Uptake in Noodle kg	Water Supply Inlet m^3	Estimated Wastewater Outlet m^3
1	1	220	477	257	4.952	4.7
	2	220	482	262	5.572	5.3
2	1	240	514	274	7.327	7.1
	2	280	634	354	6.555	6.2
3	1	180	336	156	1.817	1.7
	2	230	466	236	2.650	2.4
4	1	150	300	150	2.962	2.8
	2	150	300	150	2.731	2.6
5	1	150	347	197	4.471	4.3
	2	150	300	150	4.749	4.6
Average ($\bar{x}$)		192	415.6	218.6	4.379	4.2
SD		47.2	115.1	69.6	1.814	1.8

According to Table 1, the average unit wastewater flow is calculated to be 21.3 l/kg rice cake used or 10.1 l/kg noodle produced.

The wastewater samples were taken as 1-hr composite samples, i.e. from 6 equal volume mixtures of samples collected at 10-min interval. The sampling periods varied from 2 to 6 hr during production. The analytical results varied significantly, both hourly and daily. The daily average data are summarized in Table 2.

Table 2. Wastewater Characteristics from Khanomjin Production

Parameter	Factory 1		Factory 2		Factory 3		Factory 4		Factory 5		Average ($\bar{x}$)	SD
	Day1	Day2	Day1	Day2	Day1	Day2	Day1	Day2	Day1	Day2		
COD, mg/l	1322	1642	1893	1568	2593	2930	1808	2208	1777	1533	1927	505
NH_3-N, mg/l	0.51	0.51	0.14	0.14	0.14	0.14	0.18	0.14	0.14	0.10	0.21	0.16
Org-N, mg/l	0.60	0.70	0.42	0.42	0.42	0.42	1.22	0.56	0.84	0.45	0.60	0.26
TP, mg/l	1.51	1.36	-	1.18	1.50	2.30	2.54	2.33	1.40	1.50	1.74	0.51
SS, mg/l	4420	-	-	4770	1100	1690	1530	1230	910	910	2070	1585
VSS, mg/l	4260	-	-	4680	1070	1650	1460	1180	880	880	2008	1547

It was found that the wastewater consisted of relatively high suspended solids (SS), mainly from cooked rice cake and appearing in slightly milky color. The majority of solids is organic matters due to high ratio of volatile suspended solids (VSS) : suspended solids, i.e. 0.97. The COD concentration varied from 1322-2593 mg/l with average value of 1927 mg/l. It is approximately 7-10 times higher than domestic wastewater. The average ratio of COD : total kjeldahl nitrogen (combination of organic nitrogen (Org-N) and ammonia nitrogen (NH_3-N)) : total phosphorus (TP) is 100:0.04:0.09. The required ratios for anaerobic and aerobic treatment are 100:1.1:0.2 (McCarty, 1964) and 100:5:1, respectively. This indicates the insufficient nutrients (N, P) in waste stream. According to this study, the unit pollution load was found to be 41.0 g COD/kg rice cake used or 19.5 g COD/kg noodle produced

The pollution load generated by Khanomjin producers in this village is estimated in Table 3. It is assumed that 2 rice cake producers generate loading equal to 4 noodle producer, thus making total number of producers to be 27.

Table 3. Estimated Water Pollution Load from Khanomjin Production in Huay Nam Rin village

Item	Unit Load From Khanomjin Producer	Water Pollution Load		
		From All Khanomjin Production	From Domestic Wastewater(1)	Total Load
Wastewater Flow rate, m^3/d	4.2	113.4	199.4	312.8
COD Load, kg/d	8.1	218.7	39.9	258.6

Remark: (1) Total population 1662, unit wastewater flow and COD are estimated to be 120 l/(person.d) and 200 mg/l, respectively.

It was found that the wastewater from Khanomjin production contributed to total community load around 64% in terms of volume while the figure went up to 85% in terms of organic load.

It is obvious that such a large cluster of household industry can result in significant pollution loads to receiving water bodies. Wastewater treatment, either at pretreatment or fully treatment steps, is required. The field surveys showed that the Khanomjin wastewater eventually flowed to a small stream which ended up in nearly paddy field. Considering the total noodle production estimated at 9.8 ton/d, it is clear that this activity is one of the backbone economy of the village. A lot of villagers have shared the benefits and this may help alleviate the public conflicts on water pollution problem.

The interview results of 4 factory owners revealed that they were aware of wastewater problems. However, due to present industrial law which does not cover household industry, they were reluctant to invest in individual treatment facilities and be unpreferrable with the difficulties which may occur during operation and maintenance (O&M). If central treatment plant is constructed by government budget, they agreed to pay for O&M cost at 100-600 Baht/mo. The financial survey estimated that the monthly incomes per producer were around 90,000-150,000 Baht/mo. The estimated profits were 26,000-64,000 Baht/mo while the interviewed figures ranged from 7,500-30,000 Baht/mo. The estimated profits are in the range of middle to high incomes family in Thailand.

The laboratory-scale study on pretreatment of Khanomjin wastewater by upflow anaerobic sludge blanket (UASB) reactors were conducted by authors. Due to insufficient experimental period, no concrete conclusion on optimum organic loading rate and efficiency can be drawn.

Under the present circumstances; small entrepreneur (2-3 workers), little investment, simple technology as well as not required by law concerning wastewater treatment, the following strategies are suggested.

- **Local Guideline,** the health official jointly with the village administration can set up local guideline or regulation concerning wastewater treatment. This guideline must not be so stringent and be agreeable by all parties concerned. It is suggested that individual pretreatment facility aims for 50% COD reduction may be reasonable. However, it is not sure whether enforcement can be applied to uncooperated producers or not.
- **Incentive,** the health official may be able to subsidize some basic construction materials such as cement, sand, etc. similar to other health promotion programs, such as toilet construction. However, there is very little possibility to subsidize the central treatment plant.
- **Social Sanction,** the village administration may use social sanction to the Khanomjin producer although it is doubtful about the results.

- **Technology Development,** the appropriate technology for this case is not yet available or onsite demonstrated. The possible systems are UASB reactor, anaerobic filter, septic tank and other anaerobic processes which require less space (most producers have limited spaces), simple in O&M and low construction cost. It is suggested that some selected systems be investigated and field tested. The affordability of selected systems should be also emphasized.

There is no information concerning Khanomjin consumption and production in Thailand. However, it is obvious that this fresh noodle is available throughout the country. With a rough estimate by authors that only 23 producers from this village have supplied Khanomjin to Chiang Mai municipality, the average consumption rate is calculated to be around 0.05 kg/(person**.**d). The country-wide daily consumption may be around 3,100 ton with over 7,400 producers scattering throughout Thailand. The organic load from all Khanomjin producers is estimated to be 59,900 kg COD/day while the wastewater flow rate may reach 31,000 m^3/d. The objective of the presented figures is to stress that this household industry can significantly affect the water bodies, if heavily clustered, and remediation action should be seriously considered. The implementation of pretreatment step with appropriate and afforable technology is highly recommended.

4. CONCLUSIONS

The unit wastewater flow from Khanomjin production was found to be 21.3 l/kg rice cake used or 10.1 l/kg noodle produced. The average characteristics of wastewater are as follows; COD 1927 mg/l, NH_3-N 0.21 mg/l, Org-N 0.60 mg/l, TP 1.74 mg/l, SS 2070 mg/l, VSS 2008 mg/l. The wastewater has insufficient macro nutrient (N, P) for wastewater treatment with COD:TKN:TP ratio of 100:0.04:0.09. The average Khanomjin producer generated 415.6 kg fresh noodle/d while discharged the raw wastewater at 4.2 m^3/d to receiving water body. The unit organic load was found to be 41.0 g COD/kg rice cake used or 19.5 g COD/kg noodle produced. Due to high number of producers in the study area, the Khanomjin wastewater contributed to total community load around 64% in terms of volume and around 85% in terms of organic load. The average producer is estimated to earn profit around 26,000-64,000 Baht/mo which should be sufficient to support simple wastewater treatment facility such as pretreatment unit. Since it is not required by law, various strategies must be drawn to encourage the producers to treat their wastewater.

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