

Investigation of Excess Sludge Generated from Activated Sludge Treatment Plant of Concentrated Latex Factories: An Investigative Case Study in Southern Thailand

Wanrudee Wanseng^{1*}, Somtip Danteravanich^{2,3} and Panalee Chevakidagarn^{1,3}

¹Faculty of Environmental Management, Prince of Songkla University, Hat Yai Campus, Songkhla 90110, Thailand

²Faculty of Science and Industrial Technology, Prince of Songkla University, Surat Thani Campus, Muang, Surat Thani 84100, Thailand

³National Excellence Center for Environmental and Hazardous Waste Management-Satellite Center, Prince of Songkla University, Hat Yai 90112, Thailand

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* Corresponding author:

E-mail:
pook024@hotmail.com

ABSTRACT

Activated sludge technology has been employed for wastewater treatment in the concentrated latex factories in the south of Thailand. This paper highlights the survey results of the excess sludge generated from activated sludge treatment plants of the concentrated latex factories, including sludge generation rate, sludge characteristics, as well as sludge management and its problems. The total number of 11 factories was investigated. The findings showed that 20% of the investigated factories using activated sludge did not know how much the excess sludge generation rate was. With an in-depth investigation, the excess sludge generation rate was determined as for 28 kg/ton concentrated latex product or 10 kg/ton of field latex used in the concentrated latex factories. The excess sludge had a low C/N ratio with an average value of 4.7 and contained N, P, and K with the average of percentage values of 8.0, 2.0, and 1.0% dry basis, respectively. However, the excess sludge consisted of Zn with an average of 3.01% dry basis. 60% of the investigated factories using an activated sludge system had issues concerning the management of excess sludge. Moreover, various aspects of the excess sludge management were discussed and lessons were learned on the current excess sludge management of the concentrated latex industry in the south of Thailand.

1. INTRODUCTION

Hevea brasiliensis, natural rubber, was brought into Thailand during 1899-1901 (Suongwatin, 2012). Since that time, Para rubber industry has been developed and catapulted Thailand to become the world's largest producer and exporter (Danteravanich et al., 2007a; Danteravanich et al., 2009; Intapun et al., 2009). However, among the rubber industries, the concentrated latex industry has boomed in the south of Thailand. In 2002, it was reported that there were only 55 concentrated latex factories in the south of Thailand, but by 2014 the number had grown up to 68 factories (Danteravanich et al., 2007b); Department of Industrial Works, 2014). The production process of concentrated latex consumes large amounts of water resulting in high wastewater generation. The concentrated latex wastewater has

high concentrations of organic matter, nitrogen and sulfate contents. The main contributions to high contents of such pollutants due to the rubber serum contained in wastewater are the use of ammonia and sulphuric acid for the preservation of latex and the coagulation of skim latex, respectively. The concentrated latex factories in Southern Thailand commonly use stabilization ponds, including anaerobic, facultative and aerobic ponds, as well as aerated lagoons to treat their wastewater. However, as the factories have a constraint due to limited land, and public complaints from the residents in the nearby urban areas of malodor, activated sludge technology has been employed for wastewater treatment system (Rakkoed et al., 1999; Prabnakorn, 2000; Danteravanich et al., 2007b). In 2002, activated sludge process was reported to be used in only 5

concentrated latex factories in the south of Thailand (9% of the concentrated latex factories) (Danteravanich et al., 2007b), but 43% of them (29 factories from the 68 factories) were reported to utilize the activated sludge process in the concentrated latex factories in 2014 (Department of Industrial Works, 2014).

The activated sludge system is a high effective wastewater treatment process, but resulting in excess sludge waste generation. Activated sludge waste is the excess sludge intentionally removed from the activated sludge system. The sludge consisted almost entirely of microorganisms from the activated sludge aeration tanks. Whenever the activated sludge wastewater treatment system is operated, an inevitable by-product of bio-residual solids or excess sludge (bio-solids) is generated. The amount of excess sludge generated depends upon how much wastewater is treated and whether the sludge is pretreated. The sludge usually consists of volatile solid content, typically ranging from 75-85 %. However, it is noted that these bio-solids could not be easily degraded in the digester to the same extent as the raw primary sludge. This is because these bio-solids consist of complex organic content of microorganisms and resulting resistance of degradation (California State University and California Water Pollution Control Association, 1993). Due to the increased number of activated sludge system employed for the wastewater treatment in the concentrated latex factories in the South of Thailand, it is anticipated that excess sludge volume would have been increased significantly. Depending on the quantity of excess sludge generation, the factories have the responsibility to adopt their own approaches to treat and manage such excess sludge. In addition, the increased stringency of the regulations on industrial solid wastes control has been conducted due to the enforcement of industrial law in Thailand. The concentrated latex factories employing an activated sludge treatment process might have encountered a significant problem and limitation on excess sludge treatment and management.

In this paper, the survey results of excess sludge management of the concentrated latex factories in the south of Thailand are reported. The excess sludge of the concentrated latex factories in Southern Thailand was investigated in order to know the current situation of bio-solids sludge

management and subsequently enable understanding of the limitation/controversial aspects of the factories encountered with such excess sludge management. The paper does not only address current excess sludge management and problems related to it, but also states various aspects of the discussion and lessons learned regarding the present excess sludge management of the concentrated latex industry in the south of Thailand. This information report aims to be useful for the concentrated latex industry and the concerned academic agencies/organizations in the south of Thailand to further support as well as strengthen the knowledge, competency, skills and technology for the concentrated latex industry, in particular environmental personnel who have the duty to manage bio-solids control and to carry out management in the right direction.

2. METHODOLOGY

In this study, the information on the generation, characteristics, treatment, use and disposal of excess sludge generated from activated sludge treatment plant of the concentrated latex factories in Southern Thailand was collected through a two-part survey. The details of the survey are described as follows.

In the first part of the study, secondary information collection and questionnaire were used. Secondary data related to the database of the concentrated latex factories located in the south of Thailand, as well as their wastewater treatment systems were reviewed and used to get the target factories for questionnaire study. A questionnaire survey was used to acquire the information concerning the technicality, management and limitation of the excess sludge practices implemented by the factories. The questionnaire was developed by the researchers to collect preliminary information. From the database of the Department of Industrial Works in 2014, 29 concentrated latex factories in the south were reported to employ an activated sludge process as a main treatment system. Therefore, 29 questionnaires were directly sent by mail to the target concentrated latex factories, which used the activated sludge system. Only 11 of them (38%) fully answered the questionnaire and returned it to the researchers. The returned questionnaires were edited and analyzed. Data from the returned questionnaires were cross-

checked with the information undertaken from the field survey in the second part of the study.

In the second part of the study, factory visiting, interviews, and excess sludge sampling were conducted in the 7 concentrated latex factories that had returned the completed questionnaires and accepted the field visit request. Excess sludge sampling was undertaken during each factory visit. Moreover, one concentrated latex factory was selected for in-depth investigation and monitoring of sludge characteristics and generation rate. The in-depth study was conducted over 7 months to determine whether the physical and chemical characteristics of the waste activated sludge showed any difference resulting from the influence of the seasons of field latex cutting; at the new open cutting (April-May), and at the normal cutting (June-October). A total of 20 sludge samples were determined for physical and chemical characteristics. The following characteristics of the sludge samples were examined: MC (moisture content), pH, N, P, K, VS (volatile solids), OM (organic matter), Na, Ca, ash, density and Zn. In addition, heavy metals in terms of As, Cu, Cr, Cd, Hg, Pb, Mg, and Al were determined in some excess sludge samples. The sludge characteristics were determined according to the procedures of the AOAC (1990) and the standard methods for the examination of water and wastewater described by APHA, AWWA and WEF (2005). The statistical analysis of the characteristic data of sludge samples was carried out by using max, min, mean and standard deviation values. In order to determine the influence of the field latex cutting seasons on the chemical characteristics of excess activated sludge samples, the parametric statistic of t-test and f-test were conducted at the 0.05 significance level.

For the concentrated latex factory where the monitoring of the generation rate of the excess sludge produced from the activated sludge process was conducted, the daily generation rate of the sludge was determined by weighing dewatered excess sludge. The sludge generation rate was monitored for 7 months. In addition, during the sludge generation rate investigation, the data concerning the field latex consumption, the concentrated latex production, the wastewater generation, and the chemicals utilization at excess sludge conditioning and dewatering steps were also collected. All such data obtained were used to

calculate the waste activated sludge generation rate based on the treated wastewater and the concentrated latex production as well as on the field latex consumed.

In addition, statistical analysis was carried out on the data obtained in terms of percentage, mean, and SD (standard deviation) values. The results obtained from the first and second parts of the survey were used further as the basis for several recommendations and for discussion of waste activated sludge pollution and its management.

3. RESULTS AND DISCUSSION

3.1 Background of concentrated latex factories employing an activated sludge system

From the secondary data review, it was found that in 2014, there were 68 concentrated latex factories located in 10 provinces out of the total 14 provinces in the south of Thailand (Figure 1). Songkhla province has the largest number of the concentrated latex factories and the second largest was found in Trang province. 29 (43%) concentrated latex factories out of total factories employing activated sludge treatment plants. The largest number of concentrated latex factories employing activated sludge treatment plants was observed to be in Songkhla province while the second and third were found in Trang, and Surat Thani provinces, respectively.

From the questionnaire survey, the demographic characteristics of the respondents working in the concentrated latex factory were determined and found to be as follows. The majority of the respondents were aged ranging from 35-40 years (50%) and 50% of them had over 10 years work experience in the factory. 80% of them worked in the positions relating to industrial environmental management, namely, environmental manager and environmental supervisor. Most of the respondents had a Bachelor's degree (70%) and the rest (30%) had a Master's degree. In addition, 80% of them had a monthly income in the range of 25,000-30,000 baht. These results reflected that the respondents could really give factual information on the background of concentrated latex factories that used activated sludge systems. However, with the data cross-checked from the field study, the information of target concentrated latex factories investigated was described as follows.

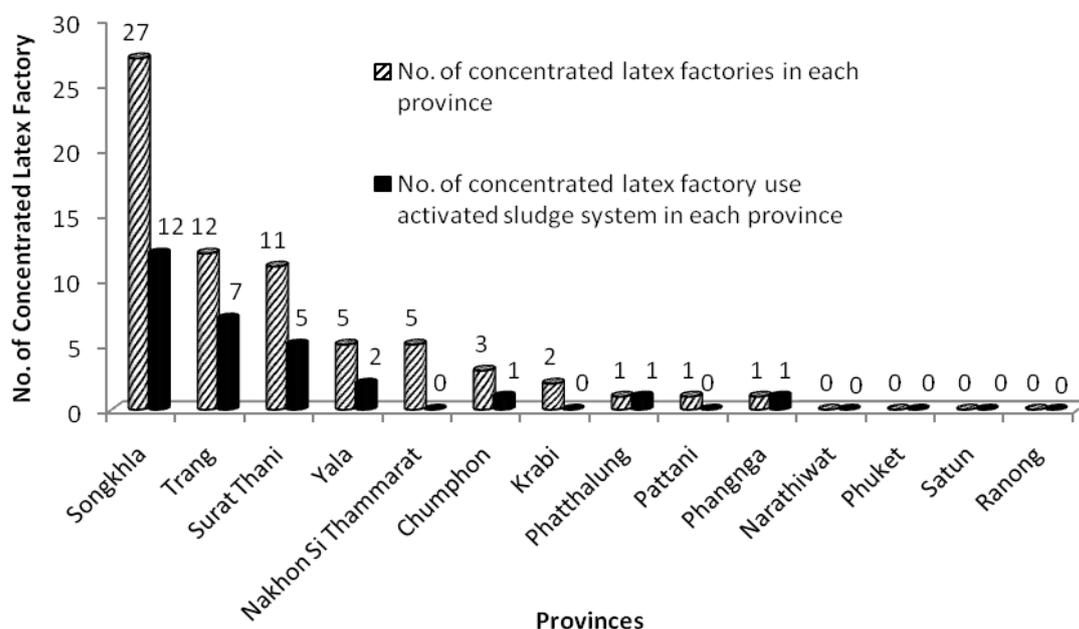


Figure 1. Number of the concentrated latex factories using an activated sludge system in each province in the south of Thailand.

The concentrated latex production rates of the investigated factories that used the activated sludge process were found ranging from 71- >300 ton/day. 72% of them had a concentrated latex production rate ranging from 101-200 ton/day. Actually, a concentrated latex factory has 2 production lines of concentrated latex and skim block rubber processes. The concentrated latex is produced from field latex and has skim latex by-products. The skim latex is coagulated with H_2SO_4 acid and used additionally to produce skim block rubber (Danteravanich et al., 2007b; Danteravanich et al., 2009). However, the results obtained showed that the investigated latex factories did not only produce the concentrated latex and the skim rubber, but some of them (20%) produced STR20, STR5L and dry rubber sheets. Among the concentrated latex factories, which used the activated sludge system, it was found that 55% of them generated wastewater with a volume of more than 300 m^3/day , and 36% and 9% of them produced wastewater at the rate of 101-300 m^3/day and less than 100 m^3/day , respectively. It should also be noted that 9% of the factories did not have any water pollution supervisor. This supervisor is an environmental employee, who is permitted to carry out water pollution prevention systems in a factory via inspection, supervision, control, maintenance and the operation of pollution treatment systems,

and qualified as well as registered with the Department of Industrial Works, Ministry of Industry. This is followed by the criteria addressed by the notification of the Ministry of Industry on the environmental personnel qualification announced in 2011 (Danteravanich et al., 2014, Ministry of Industry, 2011). These results illustrate that there are some concentrated latex factories in the south of Thailand using the activated sludge system for wastewater treatment, which lack qualified water pollution supervisors.

Although all the investigated factories used the activated sludge treatment plants, but other treatment systems were also found to be used with the activated sludge system. It was found that 90% of the factories used pond systems to treat wastewater. Those were anaerobic ponds, facultative ponds and polishing ponds. Other than activated sludge and pond systems being used in the concentrated latex factories, it was also found that 10% of the factories used constructed wetlands for tertiary treatment of wastewater. The pond system, in particular the polishing pond, and the constructed wetlands were utilized as a following treatment process after the activated sludge process, while the anaerobic and facultative ponds were used as the biological treatment system before the activated sludge process. These results obtained were similar

to those presented in the previous report of Danteravanich and team in 2007 (Danteravanich et al., 2007b). Moreover, it was found that most of the factories used a coarse bubble diffuser as aerator in the aeration tank for the activated sludge process. In addition, MLSS (mixed liquor suspended solids) in the aeration tank was maintained to be in the range of 1,000-5,000 mg/L or with an average value of 2,430 mg/L.

3.2 Excess sludge generation rate

Excess sludge wasting aims to remove the microorganisms in the aeration tank, thus maintaining the balance of the amount of microorganisms and food (BOD or COD) (F/M ratio). From the study, it was found that 70% of the investigated concentrated latex factories using an activated sludge process to treat their wastewater generated waste activated sludge (before dewatering) with a range of less than 10 m³/day to 20 m³/day. It was noted that 20% of them did not know what the excess sludge generation rate was. After the excess sludge was discharged from the clarifier, it was pretreated by chemical conditioning and dewatering to give it a solid form. Based on the volume of dewatered waste activated sludge generation, it was found that 60% of the concentrated latex factories known had a sludge generation rate in a range of less than 1 m³/day to 3 m³/day, and the rest of the factory (40%) produced the dewatered sludge ranging from more than 3 m³/day to 10 m³/day.

However, based on the in-depth survey of the concentrated latex factories using an activated sludge process, input could be determined using the production process, and wastewater and excess sludge generation, as presented in Figure 2. It was observed that, with the average values, the factory used water for the concentrated latex production process at the rate of 2.56 m³/ton, and generated total wastewater amounting to 504 m³/day (310 m³/day from the concentrated latex process and 194 m³/day from the skim rubber process). This wastewater was treated by the activated sludge process, and the average dewatered waste activated sludge generated daily was 3.1 ton, or in the range of 0.54-5.6 ton/day. These data could be used to determine the average generation rates of dewatered waste activated sludge of the concentrated latex

factory based on 1) treated wastewater, 2) concentrated latex product, and 3) used field latex at 6.2 kg/m³ of treated wastewater, 28 kg/ton of concentrated latex product and 10 kg/ton of used field latex, respectively. Moreover, the generation rates of sludge during the open cutting and the normal cutting seasons were observed to be in the ranges of 1.4-3.6 ton/day and 0.54-5.6 ton/day, respectively, or to be equal to the average values of 2.98 and 3.23 ton/day, respectively. The generation rate of the waste activated sludge during the open cutting was found to be lower than in the normal cutting period. This was because the factory produced concentrated latex products and generated wastewater during the normal cutting seasons more than in the open cutting times. The higher wastewater was treated in the activated sludge system; larger biomass was produced and needed to be removed from the system. Excess sludge is used to control the biomass in aeration tanks when a change is desired, especially in the system characteristics, rather than steady-state conditions. Typically, the concentrated latex factory wasted excess activated sludge by draining a portion of the returned activated sludge flow, which had a higher concentration of suspended solids, resulting in less liquid to be dealt with in the sludge conditioning and dewatering processes. Activated sludge wasting could be a computational simplicity for controlling SRT (sludge retention time) (Water Environment Federation, 1996). The operators of the investigated concentrated latex factories usually controlled the activated sludge process running at an SRT of 25-30 days, whether under normal or open cutting conditions; therefore, the wasting rate of excess sludge was differently performed during the open cutting and the normal cutting. In addition, as to the average amount of waste activated sludge generation rate, it can be estimated that 356 kg of dry solid waste activated sludge was generated a day. This was calculated based on the average moisture content of 88.5% of sludge (Table 1). These dry waste solids from wastewater treatment were quite similar to those in Kritsamphan's report in 2013 that reported the excess activated sludge of one concentrated latex factory in the south of Thailand was wasted at 244 kg/day (Kritsamphan, 2013).

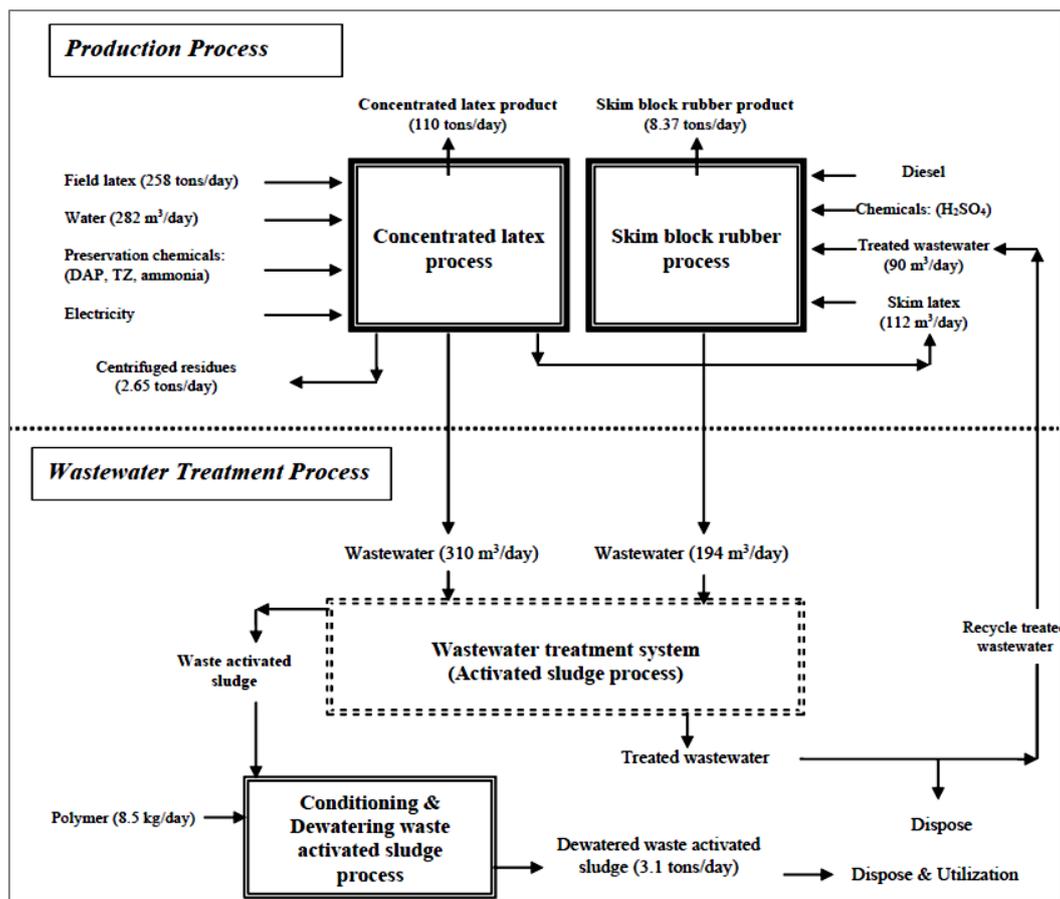


Figure 2. Summary flow chart of production processes, wastewater treatment and wasted sludge from wastewater treatment of the in-depth examined concentrated latex factory

3.3 Excess sludge characteristics

Information of excess sludge characteristics was needed for sludge utilization and disposal. Table 1 presents physical and chemical characteristics of the samples of excess sludge generated from the activated sludge plant of the concentrated latex factories. Most of the excess sludge samples were dewatered or thickened. The average values of density, pH and moisture of the waste activated sludge from the concentrated latex factories were found to be 1.03 ton/m³, 6.73, and 88.5%, respectively. The chemical characteristics revealed that the excess sludge had high levels of volatile solids or organic matter, with average values of 70% and 47%, dry weight, respectively. This was because the sludge mainly consisted of biological solids synthesized in the aeration tank of the activated sludge system. Moreover, the sludge was determined to compost of relatively high levels of plant nutrients. The average contents of N, P, and K were found to be 8.0, 2.0, and 1.0% dry basis,

respectively. It was noted that the sludge consisted of a high concentration of N. It was observed that the activated sludge samples from the factory without chemical conditioning process contained lower N concentrations. Therefore, the high N concentration in waste activated sludge samples from some factories might have been caused by the contamination of polyacrylamide polymer used in the chemical conditioning process of the waste sludge. In addition, the C/N ratio of the sludge was found to be in the range of 2.1-13.5 or equivalent to an average of 4.7. This implied that the waste activated sludge had a very low C/N ratio.

However, Zn concentrations in the excess sludge were determined as ranging from 0.22-7.16 % dry basis or equal to an average value of 3.01%. When the sludge was analyzed for levels of other metallic elements, it was found that heavy metals, in terms of Al, As, Cd, Cr, Cu, and Pb were determined to be in the ranges of 152-628, 0.47-0.49, 0.64-0.66, 6.45-6.65, 12.54-18.93, and 6.78-

7.14 mg/kg, dry weight, respectively and Mg was in the range of 0.42-1.69%, dry basis. However, Hg was less than the detection limit with a value of 0.01 mg/kg, dry basis. These data reflected that the excess sludge relatively consisted of high concentrations of heavy metals in terms of Zn, Mg and Al. Heavy metals contained in the activated sludge due to the wastewater containing heavy metals, and also because of the occurrence of biosorption of the heavy metals on the bio-sludge (Dhokpande et al., 2014). The concentration of Zn

in the sludge was quite high due to ZnO being used in the concentrated latex production process. ZnO was mixed with tetramethyl thiuram disulphide (TMTD) then called TZ dissolved liquid and used for latex preservation in the production process (Danteravanich et al., 2004, Tekprasit, 2000). Mg was generated mainly from rubber serum, and Al might have come from the polymer (PAC: Polyaluminium chloride) used in the rubber recovery process of centrifuged residues of the factory.

Table1. Characteristics of excess sludge generated from the activated sludge plant of concentrated latex factories

Parameters	Samples during open cutting		Samples during normal cutting		All samples	
	Range	Mean \pm SD	Range	Mean \pm SD	Range	Mean \pm SD
Density (ton/m ³ , wet basis)	1.15-1.27	1.19 \pm 0.17	0.77-1.17	0.97 \pm 0.16	0.77-1.27	1.03 \pm 0.17
pH	6.65-6.91	6.08 \pm 0.13	6.25-7.19	6.71 \pm 0.33	6.25-7.19	6.73 \pm 0.29
MC (%)	88.9-90.7	89.5 \pm 1.0	87.5-89.0	88.2 \pm 0.48	87.5-90.7	88.5 \pm 0.84
N (% dry basis)	1.8-11.1	6.0 \pm 4.0 ^a	8.5-11.5	10.3 \pm 1.21	1.8-11.5	8.0 \pm 3.7
P (% dry basis)	0.87-4.5	2.4 \pm 1.3 ^b	1.3-1.9	1.6 \pm 0.20	0.87-4.5	2.0 \pm 1.0
K (% dry basis)	0.56-2.5	1.2 \pm 0.64 ^b	0.70-0.95	0.81 \pm 0.09	0.56-2.5	1.0 \pm 0.49
VS (% dry basis)	22-86	59 \pm 25.5 ^a	71-87	83 \pm 6.19	22-87	70 \pm 21.9
Ash (% dry basis)	14-78	41 \pm 25.5 ^a	13-29	17 \pm 6.16	13-78	30 \pm 21.9
OM (% dry basis)	32-62	47 \pm 9.68 ^b	40-63	47 \pm 7.29	32-63	47 \pm 8.40
OC (% dry basis)	19-36	27 \pm 5.62 ^b	23-37	27 \pm 4.23	19-37	27 \pm 4.87
Na (mg/kg, dry basis)	201-406	316 \pm 105 ^b	208-456	344 \pm 81	201-456	337 \pm 1.34
Ca (mg/kg, dry basis)	1101-1297	1207 \pm 99 ^b	911-5848	1890 \pm 1822	911-5848	1719 \pm 1585
Zn (% dry basis)	0.22-7.16	3.31 \pm 1.81 ^b	1.72-3.19	2.70 \pm 0.56	0.22-7.16	3.01 \pm 1.34

^a Shows the statistical differences at $p < 0.05$ of sludge samples taken due to rubber cutting seasonal variations.

^b Illustrates no statistical differences at $p < 0.05$ of sludge samples taken due to rubber cutting seasonal variations.

The concentrations of MC, VS, N, and Zn of the excess sludge investigated in this study were similar to the activated sludge from the concentrated latex investigated by Kritsamphan (2013) who reported that the excess sludge consisted of MC, VS, N, and Zn in the ranges of 74-98%, 12-82%, 1.0-10.7%, and 0.03-1.77%, respectively.

When statistical analysis was utilized to test the chemical characteristics in terms of N, P, K, VS, ash, OM, OC, Ca, Na, and Zn contained in the sludge samples taken during the open cutting and the normal cutting, it was found that rubber cutting seasonal variations had significantly influenced some chemical characteristics of waste activated sludge, in particular, N, VS and ash contents (Table 1). However, the results illustrated that the average values of P, K, OM, OC, Na, Ca, and Zn in the

sludge were not observed to be different during the open cutting and the normal cutting. The chemical characteristics of the excess sludge samples presented in Table 1 reflect that this organic sludge had relatively high levels of plants nutrients, but still contained high Zn content; therefore, the impact of the utilization of this sludge as a compost material or used in land disposal should be considered. In addition, with reference to Thailand's regulations on hazardous waste, waste was defined as hazardous if the concentration of hazardous pollutants was higher than TTLC (total threshold limit concentration) value and/or was higher than STLC (soluble threshold limit concentration) value. The TTLC of Zn was announced to be not more than 5.000 mg/kg based on wet weight (Ministry of Industry, 2006). Comparison of the TTLC value of Zn and the

average Zn concentration of 3,462 mg/kg, in terms of wet basis, determined in the excess sludge from the concentrated latex factories, it could be said that this excess sludge was not hazardous waste. However, if the moisture in the sludge had been reduced more, or for example, by 83%, then it could have been defined as hazardous waste due to the concentration of Zn being more than the TTLC value.

3.4 Excess sludge management, problems, limitations and recommendations

From the survey questionnaire, the method to handle and manage excess sludge generated from the activated sludge plant of the concentrated latex factories in the south of Thailand was observed and described as follows: only 40% of the factories used conditioning and dewatering sludge before disposal or utilization. The rest of them did not dewater the sludge, but kept it in ponds, let it dry in sunlight and used it for landfill, or else it was disposed of in oil palm or rubber plantations. In the group of factories dewatering the sludge, chemical conditioning was commonly performed by using polyacrylamide before sludge dewatering. This polymer was used at a rate ranging at 2.54-2.67 kg/ton dewatered sludge or at a range of 0.8-85 kg/day. It was intended that the polymer used should enhance the separation of water from the bio-solids particles. After the conditioning step, the sludge was further dewatered. It was found that there were several mechanical dewatering systems used in the factories. Typically, dewatering used in the concentrated latex factories was associated with the equipment utilized in the process. Most sludge dewatering systems found in the concentrated latex factories included belt filter presses and pressure filters. From the survey results, it was found that 50% of the factories doing sludge dewatering used belt filter presses while 25% of the factories used pressure filters. The dewatered sludge was further processed by utilization and disposal. It was found that 60% of this factory group used the dewatered sludge as fertilizer in oil palm and rubber plantations, 10% used it as landfill, 10% utilized it as soil conditioner, and 20% was dried and used to make fertilizer. It was noted that after the waste activated sludge was dewatered, it was not biologically treated before utilization or disposal. In terms of sludge management cost, it was observed that 50% of the concentrated latex factories using

activated sludge did not know the cost, but 30% of the factories had monthly operation costs of waste activated sludge varying from 5,000-10,000 baht (equivalent to 125-250 USD), and the remaining 10% of them had costs ranging from 30,000-50,000 baht (equivalent to 750-1,250 USD) per month.

The solid waste streams in the concentrated latex factories come from 2 main sources that are the production process and the wastewater treatment system. The respondents of the survey questionnaire in the concentrated latex factory revealed that 40% of them did not have any problems of solid waste management, but 30% and 10% faced problems from rubber traps and centrifuge residues, respectively. In addition, 60% of them said that they had problems with the waste activated sludge. Additionally, the survey results reflected that waste activated sludge problems of the concentrated latex factories using the activated sludge system to treat their wastewater was determined, as shown in Figure 3. It was observed that 40% of the factories determined that they could not utilize the waste activated sludge and were having the problem with the high operation costs for the waste sludge management while 20% and 10% of the factories were facing a waste sludge malodor problem, and the issue concerning inadequate knowledge on sludge management, respectively. Furthermore, the remaining 10% encountered a shortage of areas to dispose of the waste activated sludge.

Figure 4 presents the needs of the concentrated latex factories using an activated sludge system to improve the waste activated sludge management. It was observed that 60% of the factories needed to learn more about the waste activated sludge management, and wished to adopt a low cost sludge management technology and use the waste activated sludge. 50% of the factories wished to utilize more waste sludge, and another 30% of the factories wanted to find more disposal sites for the waste sludge.

Activated sludge technology is perhaps employed more widely for the wastewater treatment in the concentrated latex factories in the south of Thailand. Looking at the survey results, it is anticipated that there would be more issues concerning the waste activated sludge management if it is improperly implemented. Moreover, due to the stringency enforcement of the industrial solid waste management regulations on the industrial

sector, the concentrated latex factories using an activated sludge system will have a significant impact on the responsibility of waste activated sludge management and mandated higher levels of bio-sludge management will be required. Proper waste activated sludge management requires a good understanding of sludge characteristics and various available techniques to handle the pretreatment, the treatment, the utilization and the disposal, as well as the effects control of each process on overall steps of sludge management.

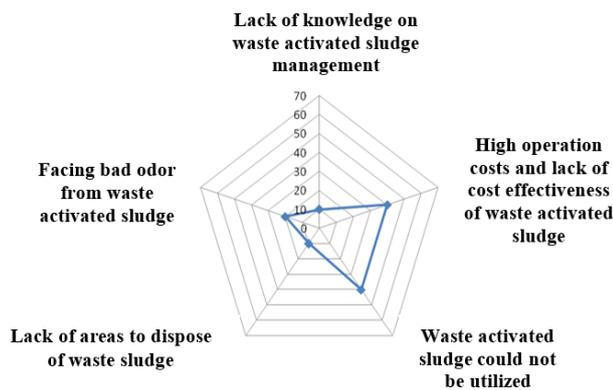


Figure 3. Types of problems relating to the waste activated sludge management of the concentrated latex factories

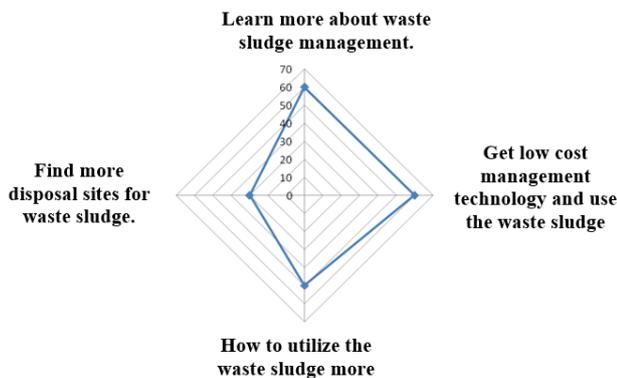


Figure 4. Need demand relating to the waste activated sludge management of the concentrated latex factories

As mentioned above, a large volume of waste activated sludge was generated, which had potential benefits as biomass resources, including organic matter and plant elements, especially N, P, K, that could enhance soil quality and support nutrients for plant growth. However, the study results revealed that this sludge might be classified as hazardous waste, in particular terms of Zn contamination,

depending on the moisture content. Therefore, in the case that the sludge was directed toward beneficial utilization, especially agricultural land application or used as sludge amendment material, knowledge of heavy metals concentrations in the sludge would be needed to assess whether there would be any potential risks to the environment. In addition, a new approach, especially under the utilization concept of this sludge without heavy metal impact, should be considered in order to improve the efficiency of the sludge management. However, this concept of sludge utilization technology should be further investigated. The technology is needed to verify further that from sludge high value-added material for utilization can be generated which can be both cost-effective and environmentally acceptable. If better knowledge regarding sludge utilization is obtained, the management practice of the sludge will be modified based on scientific understanding. More research and development efforts need to be undertaken on waste activated sludge management. These efforts will ensure the continuous improvement and the changes in actual sludge management that lead to a more sustainable sludge management for the concentrated latex factories where activated sludge systems are used. Additionally, professional supervisors for sludge management should be employed in the factories.

4. CONCLUSIONS

Although, this comprehensive survey on bio-sludge (excess sludge) generated from the activated sludge treatment plants of the concentrated latex factories in the south of Thailand shows that there were some leading concentrated latex factories, of which the excess sludge were relatively well managed, it was found that the current utilization or disposal practices of this sludge were mainly performed via agriculture land application and landfill methods. Although, this sludge was composed of volatile (organic) and plants nutrients materials, it contained relatively high heavy metals, especially Zn. Alternatives for this bio-sludge utilization and disposal need to be identified. Selecting the appropriate utilization or disposal options requires analyzing the end effects on the environment as well as the need for comparative evaluation on cost effectiveness and public acceptance. Therefore, it should still be required that excess sludge generated from activated sludge

treatment plant of the concentrated latex factories be considered for proper processing operations and cost effectiveness includes better conditioning, dewatering, stabilization, and disposal. Less efficiency of sludge management practices may influence the effectiveness of environmental management systems of the factories, and possibly cause suffering to their waste management.

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