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WATER POLLUTION IN WOOD-BASED INDUSTRIES IN THAILAND: CASE STUDY OF A HARDBOARD FACTORY

RACHANEEWAN CHAROENWANYING

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BY

RACHANEEWAN CHAROENWANYING

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APPROVAL SHEET

Name of Candidate: RACHANEEWAN CHAROENWANYING

Tittle of Project: Water Pollution in Wood-based Industries in Thailand: Case Study of A Hardboard Factory

Approved by:

....

ASSOC. PROFESSOR DR. RAZALI ABDUL KADER
(Examiner)

....

DR. ANHAR SUKI
(Examiner)

....

DR. RAZALI ABDUL KADER
Associate Professor
(Coordinator, M.S. Wood Industries Technology Programme)

....

ASSOC. PROFESSOR DR. YUSUF HADI
(Dean, Faculty of Forestry)

Date of Examination: November 1991

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DEFINITION

Biochemical Oxygen Demand (BOD) is the amount of dissovled oxygen used by microorganisms in the biochemical oxidation of organic matter for a period of 5 days at 20°C.

Chemical Oxygen Demand (COD) is used as a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant.

pH is determination of activity of the hydrogen ions by potentiometric measurement using a standard hydrogen electrode and a reference electrode.

Total Solid (TS) is the amount of material residue left after a sample is dried in an oven at a temperature of 103-105°C.

Suspended Solid (SS) is the portion of total solids retained by a 1.2 μm filter.

Total Dissolved Solid (TDS) is the portion that passes through a standard glass fiber filter.

Volatile **Suspended** Solid (VSS) is the total weight residue suspended solid loss after ignition at 550 to 600°C.

Abstract

A study of waste water characteristics from a hardboard factory was conducted in order to determine and identify the appropriateness of the waste water treatment process. The factory uses a combination of treatment processes such as the sedimentation, anaerobic and aerated process. Grab samples were used to analyse the crucial parameters of the waste water. The results show that the BOD, COD, TDS and SS values of the discharge were 31 mg/l, 409 mg/l, 2,213 mg/l and 107 mg/l, respectively, while the average removal efficiency were 99.5, 97.5, 68.4, and 90.5 %, respectively. The raw waste water shows a high loading of 10,283 kg/day BOD, 25,623 kg/day COD, 13,380 kg/day TDS and 2,158 kg/day SS. The overall treatment system has an approximate retention time of 13 days. In addition, some properties such as colour, and odour were also observed. Generally, the results of this study indicated that the waste water from the factory was properly treated in compliance with the Thai Industrial Effluent Standards.

CHAPTER 1

INTRODUCTION AND OBJECTIVES

1.1 Introduction

The present water pollution situation in Thailand is a major problem especially for the Chao Phra Ya river. The river flows through Bangkok Metropolitan whose population is approximately 10 % of the total population of Thailand (Sujarittanont, 1983). Many efforts have been made in the past to find ways to control the pollution of the river. However, only a few domestic treatment plants have been constructed so far.

Chao Phra Ya river is the most important river, located in the central part of Thailand. The river has a total length of 380 km. with a basin area of 162,000 sq.km. The upper part of the river is mainly used for agricultural purpose whereas the lower part is mainly used for industrial and domestic purposes. Since 1976 it was found that the water quality in the river is rapidly deteriorating and the Chao Phra Ya River Water Quality Survey and Monitoring Programme was then set up by the Office of the National Environment (ONEB). The existing water quality condition and sources of pollution have then been determined. It was found that water in the lower Chao Phra Ya river was highly polluted due to the discharge of waste water from industrial and domestic activities and approximately 30-40 % of the total waste load originated from industrial activity (Phadungchewit, 1986).

Wood-based industries in Thailand are generally considered as being among the worst water-polluting industries. The wood-based industries mainly produce sheet materials, manufactured from wood or other lignocellulosic materials in the form of fibers or particles to which are bound together with binding agents and other materials to improve certain properties. These industries partly solved their waste water problems long ago. At least in principle as they recover the cooking chemicals by evaporating and burning the black liquor. Although these methods could be further refined but it results in more air pollution and still there is water pollution.

In general the wood-based panels industries can be divided into four important sectors:

Veneer and Plywood

Blockboard

Particle board and

Fiberboard

In Thailand, the wood-based industries is growing fast. This is due to the high demand for wood based panels such as plywood, fiberboard, particleboard, etc. Fiberboard is a sheet material made from wood fiber or other lignocellulosic material, manufactured by interfelting of fibers (into a mat) followed by compacting through rolls or by use of platen press. Fiberboards are classified according to their density and method of manufacture. One of the members of the family of fiberboard is the hardboard.

Hardboard is a type of fiberboard which has a density between 0.80 to 1.2 g/cm^3 or 50-70 lbs/ft^3 but most of it has been manufactured with a density of about 1 g/cm^3. The hardboards industries tend to produce better and cheaper products. Hard board has a beneficial cost structure due to the possibility of using all forms of off-cut as raw material. Scrap-peelings and residual material from the various manufacturing processes are used in the production of top quality hardboard. The product can be manufactured by either a wet or dry process.

Only the wet hardboard process presents any significant water pollution potential. Water used to form and convey fibers must be drained and treated as it contains fine solids and dissolved organic chemicals placing a biochemical oxygen demand load on the water. Most hardboard mills have a capacity of 20,000-50,000 tons per year and the polluting substances were dissolved in fairly large volumes of effluent (Gran, 1972). For these reasons there was little economical incentive for taking any radical steps towards an efficient waste water control. Today most hardboard mills have to face the fact that, due to legislation, they must treat their waste water before discharge to the receiving river or stream.

At present the Thai government does not allow the cutting of timber, the wood industries have to change into wood-based panels consequently. And new investment will move into the hardboard line by using the wet manufacturing process because hardboard takes direct responsibility to fulfil the demand. The demand of hardboard in Thailand is increasing at about 30 % annually (Bartholomew, 1984). It is known that water discarded from wet manufacturing process is highly polluting. However, only scant informations are available on water pollution generated from these factories. Therefore the purpose of this study is to assess the problem of a specific hardboard factory and to monitor the effectiveness of its waste water treatment facilities.

1.2 Objective of the study

- To determine the quality and quantity of waste water generated from a hardboard factory (Thai Plywood Co.,Ltd. in Thailand).

- To assess the effectiveness of water pollution measures undertaken

1.3 Limitations of study

- Waste water from only one handboard factory was studied (Thai Plywood Co., Ltd.)

- Analysis of water pollution parameters in terms of chemical and physical properties was carried by use of grab samples. Only an estimation of flow was attempted.

1.4 Expected of results

To know the level of water pollution from the hardboard factory and its compliance to the water pollution control standards.

To suggest probable treatment water pollution from hardboard factory.

CHAPTER 2

LITERATURE REVIEW

2.1 HARDBOARD

The wood-based panels group of products traditionally includes three main types of panels, namely (FAO, 1986):

- plywood and blockboard
- particle board
- fiber board

The above characterization of the wood-based panels are based on natural wood panels i.e., veneer and plywood. While the other group is classified on raw material such as particle and fiber with panel products of insulation boards, particle boards, laminated board and hardboards. The standard definition of fiberboard which has been most clearly and accurately defined by Akers (1966), as a sheet material manufactured from wood or other lignocellulosic materials with the primary bond deriving from the arrangement of the fibers and their inherent adhesive properties. Bonding agents or other materials may be added during manufacture to increase strength, resistance to moisture, fire, insects or decay, or to improve some other property of the product. The Rome consultation (FAO, 1966) referred fiberboard as boards usually manufactured from wood chips that have been mechanically defibred or steam-exploded or from other defibred lignocellulosic materials which are bonded together in the form of panels, either compressed or non-compressed. Depending on the degree of density, the board is traditionally referred to as hardboard (compressed) and softboard or insulating board (non-compressed).

The classification of fiberboard into various types is based on (Kollmann, 1975) :

a. Type of raw material and method of fiber production;

b. Method of sheet formation;

c. Density of product (kg/m^3 or g/cm^3 or lb/ft^3)

d. Kind and place of application.

Broadly, the wood-based fiber panel materials (the fiberboard industries) are divided into three groups namely (Akers, 1966):

1. Insulation board or softboard
2. Wallboard or mediumboard
3. Hardboard

The fiberboard industry started with the aim of converting more or less worthless or very cheap wood residues into more valuable and applicable products. The prerequisite was the acquisition of a proper technology, mainly taken over from the paper industry. The fiberboard industry is rather young but has a rapid development. The fiberboard industries would prefer softwoods but hardwoods are usually cheaper and easier to obtain. For these reasons more and more blending is applied. In tropical countries indigenous wood species are utilized for the manufacture of hardboard (Kollmann, 1975). Nearly all of the species available are applicable. All wood species are actually suitable as a raw material for the production of hardboard, even when mixed. Wood of small dimensions (thinings, tops and forest waste) is also a good raw material for the hardboard industry, even if mixed in a wide range of proportions.

For hardboard, it has a much higher density and has greater rigidity than wallboard and insulation board. There are three main types of hardboard (Akers,1966) namely:

a. Medium hardboard

b. Standard hardboard

c. Tempered or super or oil tempered hardboard.

a. **Medium hardboard** : This class of hardboard has a density of between 30 lb and 50 lb/ft^3 (400 kg and 800 kg/m^3) and is produced with a thicknesses of 3/16 in to 1/2 in (4.8 mm to 12.7 mm). This particular board has a density of 37 lb/ft^3 (600 kg/m^3) and is intended as a competitor for the particle board market.

b. **Standard hardboard** : This type of hardboard is the most widely used. It has a density exceeding 55 lb/ft^3 (880 kg/m^3) and the commonest thickness is 1/8 in (3.2 mm).

c. **Tempered hardboard** : This hardboard has a density in excess of 55 lb/ft^3(880 kg/m^3). Tempered hardboard is usually of higher density than the standard type and is specially treated during manufacture to increase strength and to give added water resistance. The common thickness is 1/8 in but a 3/16 in thickness is also available.

2.2 Properties of Hardboard

The properties of hardboard vary considerably. There are differences not only due to the raw material used and the basic manufacturing process used but also resulting from subsequent processing such as gluing, impregnation, heat-treatment, and tempering. Therefore it is very difficult to compare figures for physical, mechanical, or technological properties, obtained from various sources. From the standpoint of application three types of properties tests must be considered:

a) Method of test for the general evaluation of physical and mechanical properties.

b) Quality control procedures, for use by manufacturers in order to maintain the desired quality.

c) Acceptance tests, as a means of establishing product quality in relation to specification requirements for general or for specific uses (Akers, 1966).

The density of the hardboard mainly influences the mechanical properties such as elasticity, strength, hardness, abrasion resistance, nail holding power, etc. Other physical properties such as sorption and swelling, behaviour during drying, thermal drying, thermal properties, electrical and acoustical properties also depend upon density.

Summaries of properties for hardboard are presented in Table 2.1 and the data from the Thai Plywood Company Limited is given in Table 2.2. The hardboard may be used as components in special constructions for reducing sound transmission. The mass and the continuity of construction, and the use of double-shell constructions affect the overall transmission. Perforated hardboard is becoming very popular; its use for acoustical purposes was also mentioned (Akers, 1966).

Large flat sheets of hardboards are popular due to the possibility to bend, post-form to curved shapes, easily fasten by nailing, screwing, cementing, with special systems or clips. In Scandinavia all standard hardboard is heat treated (Tempering) hardboards by treating with a drying oil and then subjecting to heat slightly increases the density but imparts superior strength and water resistance.

2.3 Application of Hardboard

There is a multiplicity of uses for hardboard more

Table 2.1 Physical and mechanical properties of hardboard

Property		Values in metric units	Values in English	Reference
Density	g/cm^3 or lb./sq.ft.	Standard		
		0.90...1.05	55...65	FAO (1958/59)
		0.88...1.05	54...65	Kollmann (1951)
		Masonite		
		1.03...1.11	63...68	Kollmann (1951)
		Oil tempered		
		1.02...1.06	63...66	FAO (1958/59)
Modulus of rupture (bending strength)	kp/cm^2 or lb./sq.in.	Standard		
		300...550	4,300...7,800	FAO (1958/59)
		280...550	3,900...7,800	Kollmann (1951)
		Masonite		
		620...780	8,800...11,100	Kollmann (1951)
		Oil tempered		
		450...700	6,400...10,000	FAO (1958/59)
Modulus of elasticity in bending	kp/cm^2 or lb./sq.in.	Standard		
		28,000...56,000	400,000... 780,000	FAO (1958/59)
		25,000...40,000	355,000... 570,000	Kollmann (1951)
		Masonite		
		67,000	950,000	Kollmann (1951)
		Oil tempered		
		56,000...70,000	8000,000...1,000,000	FAO (1958/59)
Tensile strength parallel to surface		Standard		
		210...400	3,000...5,700	FAO (1958/59)
		140...330	2,000...4,700	Kollmann (1951)
		Masonite		
		290	4,100	Kollmann (1951)
		Oil tempered		
		450...550	6,400...7,800	FAO (1958/59)

Table 2.1 (Continued)

Property	Value in metric units		Reference
Water absorption 24 h-immersion at $20^{o}C$	% weight or volume	Standard	
		14...25	Kollmann (1951)
		10...30	FAO (1958/59)
		Oil tempered	
		8...20	FAO (1958/59)
Maximum linear expansion[1]	%	Standard	
		0.60	FAO (1958/59)
		Oil tempered	
		0.40	FAO (1958/59)
Coefficient of thermal conductivity	kcal/m h ^{o}C	Standard	
	BTU, in/h sq ft ^{o}F	0.13	FAO (1958/59)
		1.10	FAO (1958/59)
		0.095	Kollmann Vol.I p.249, extrapolated
		Oil tempered	
		0.15	FAO (1958/59)
		1.20	FAO (1958/59)

[1] Change in linear dimension when a board with an equilibrium moisture constant of 50% RH is brought to equillibrium moisture content at 97% RH at $20^{o}C$ ($68^{o}F$)

Table 2.2 Properties of hardboard manufactured from Thai Plywood Company by Asplund Process.

Property	Value	
Density	800-1,200 Kg/m^3	
Water content	8-15 % by weight	
Thickness swelling	not greater than 3 mm	30 % (max.)
	greater than 3 mm	20 % (max.)
Water absorbtion	not greater than 3 mm	40 % by weight (max.)
	greater than 3 mm	30 % by weight (max.)
Modulus of rupture		
Thickness not greater than 3 mm	3.8 Kg/mm^2 (min.)	
Thickness greater than 3 mm	3.5 Kg/mm^2 (min.)	

diversified than other board. Hardboards are used with respect to panelling, ceilings, and partitions. Factory finished hardboard in ceramic-tile or other patterns is used in increasing quantities as interior wall covering in kitchens and bathrooms and as an exterior covering for houses and other buildings, as a maintenance or modernizing material in house repair and improvement, in furniture and cabinet applications as flat sheets and curved to shape for door construction, perforated for backs of radio and television cabinets, for panelling in automobiles, truck bodies, railway passenger cars and freight cars, as a lining for concrete forms (shuttering), for novelties and special items such as cut-out letters for advertising, fixtures for stores, toys, games, work bench tops, trunks etc. The U.S. War Production Board listed more than 300 uses for hardboard (Kollmann, 1975).

Standard quality hardboard is sufficiently durable for nearly all interior or exterior purposes, particularly if protected with a paint or other film. However in more recent type of plywood, face veneers are replace by hardboard. The application of hardboards are given below :

a) Acoustical board, panels specially fabricated with numerous holes, grooves or other sound traps for interior use in ceilings and walls where reduction of sound reflection is desired. Usually they are backed with an insulation material.