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THE PULP AND PAPER INDUSTRY AND ITS WATER USE

A Summary

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A Pulp and Paper Industry
A Summary

1. Introduction

This report describes the Pulp and Paper Industry. The production processes are summarized as is this industry's dependence upon enormous quantities of water. In as much as this report is intended to summarize a very complicated, multi-faceted industry, a great deal of detail has been sacrificed for brevity and for a cleaner understanding of the industry taken as a whole.

The summary is in three major parts. The first concerns size and importance of the pulp and paper industry, and includes basic statistics on pulp and paper manufacture for the world, the United States and selected other countries. Second an overview of the production processes involved in the manufacture of pulp and paper, this includes the various inputs and outputs associated with this industry. The third part of the report concerns itself with one of the major outputs of this industrial process--pollution.

2. Size and Importance of the Pulp and Paper Industry

The pulp and paper industry is the fifth largest industry, in terms value of capital assets, in the United States, the second largest industry in Canada, and is the largest industry in Finland. However, in terms of value of shipments of all manufactured goods, the pulp and paper industry in the United States, ranks tenth,[1] and this disparity between value of assets and the value of manufactured goods reflects the large capital requirements necessary to produce paper. The industry is also, despite the large capital investment required, growing at the rate of about 5% per year.[2] Statistics show even larger growth rates for areas such as Latin America (17%), Africa (25%), and the Near & Middle East (31%).[3] Per capita consumption of paper products is approaching 1.4 lbs. per day,[4] which places paper products near the top of the list of manufactured goods consumed in the U.S. on a per capita basis during 1975. As a waste residual, paper products represented more

than 3/4 of a lb. per capita/per day for the U.S. in 1966. This is a figure equal to wastes from all other packaging materials in that year.[5] Paper products are truly omnipresent, representing and ever growing demand or resources; land, labor capital, raw materials and water.

3. Manufacturing Processes

The pulp and paper industry can be divided into the two obvious categories of pulp manufacturing and paper manufacturing. Paper is, of course, the final product of the pulping process. That is the production process is linear (i.e., logging, transport, debarking, pulping, bleaching, and paper manufacture), however, for the sake of understanding, the two aspects will be dealt with separately but in their order in terms of the production process.

3.1 Manufacturing Inputs

In depicting the methods and resources seen in Table 1, it seems wise to include brief descriptions of these resource inputs as well as to list the other necessary manufacturing inputs, such as; water, power, labor, and capital.

	Mechanical	Chem-mechanical	Semi-chemical	High-yield chemical	Full chemical
Wood	x	x	x	x	x
Bamboo	x				
Bagasse				x	x
Straw				x	x
Grass (Esparto - Sabai)				x	x
Reeds (Papyrus - Flax)	x			x	x
Rags & Cotton					x
Wastepaper	x			x	x
Man-made Fibers	x				x

Table 1.

Of the fibrous raw materials used as inputs for papermaking, wood is by far the most important. Wood fibres constitute about 75% of all the fibrous raw material supply of paper mills. The remaining 25% is subdivided between wastepaper (20%), and non-wood fibers (5%), such as; bamboo, bagasse, straws, etc. This latter category is of special significance in the developing countries. These countries are often short of wood, or the woods are mixed tropical hardwood species, whose use economically, for pulp and paper manufacture, has not yet, in most cases, been properly solved.

Wood--A great variety of wood species are used satisfactorily in pulp and papermaking, however, northern conifers, especially spruce, pine, balsam or fir, and hemlock have been historically preferred.

Bamboo--About 35 pulp and paper mills use bamboo as their source of fibrous raw material. They are mostly in India and Taiwan. Of all the various raw materials available, bamboo has the greatest potential for increased utilization in papermaking.

Bagasse--The largest production of bagasse is in Latin America, about 35 mills at present. Bagasse is the fibrous raw material remaining after the juice is pressed from the sugarcane.

Straw--While there is a relatively large amount of straw, papermaking is in competition with other uses, primilarly agricultural.

Grass-(Esparto & Sabai)--Esparto is an important papermaking material in England and continental Europe, where it becomes high-grade writing and printing paper. Sabai is pulped almost exclusively in India on a small scale where, it too becomes high-quality writing and printing paper.

Reeds (Papyrus & Flax)--Papyrus, the oldest form of writing sheet was made from papyrus in ancient Egypt, and the word paper is derived from it. However, today there are no pulp mills based on papyrus. Flax, on the other hand, is grown extensively for making linen and linseed oil, and is pulped in many countries for cigarette paper.

Rags & Cotton--Rag-pulp is used for so-called rag-content papers. These papers contain a minimum of 25% rag fibre, and these papers are used for bonds, currency and other industrial specialties.

Wastepaper--An important source of material in papermaking, about 20% of all fiber used is wastepaper. Reclaimed wastepaper reduces to usable pulp with little difficulty and is used for newsprint and, after bleaching, book paper.

Man-made Fibers--For a very small percentage of paper-making the utilization of glass fibres, rayon, nylon, Orlon, Dacron, and Asbestos as raw material, have been used for many years. However, their use is highly specialized and very limited, in terms of total pulp and paper manufacture.

3.2 Nonfibrous Raw Material

Water--Enormous quantities of water are needed for pulping, and this water must be pure and almost colourless when making bleached pulp or white papers. However, the most important characteristic of water used, is its availability at a reasonable cost. For example, in the large new bleached Kraft pulp mills, water requirements are in the range of 150 to 200 cubic metres per ton, which means that for a 750-ton per day bleached sulphate pulp mill the water requirement would be of the order of 100,000 to 140,000 cubic meters per day.[6] This is for use in process; a much larger amount is required at the same mill to dilute the effluents in order not to create a pollution problem.

3.3 Power, Labor, and Capital--Inasmuch as the terms are self-evident, Tables 2 & 3 show their employment as factors of production in a more conventional format.[7]

4. Pulping and Bleaching

The pulping process can be addressed either with respect to method of production or by class of raw material used as inputs of production. A breakdown by class of input and the associated method of production is shown in Table 4.

Bleaching is difficult to deal with in that it is a stage of processing that occurs at many points in the pulping process and is regulated by decisions regarding ultimate end-product designation of the pulp from batch to batch. Suffice it to say, as evidenced by the flow chart Figure 1, that its location is arbitrarily fixed and that its function would be thought to be utilized only about 50% of the time. This is because roughly half of manufactured pulp remains in its unbleached state and of the remaining half, only a portion receives extensive bleaching, say that portion destined to become quality writing paper.

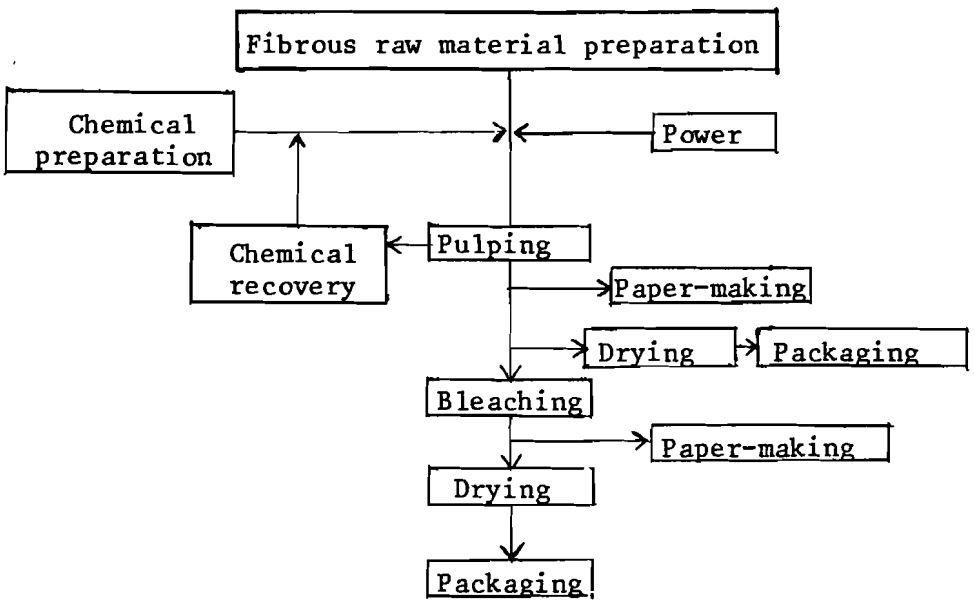


Figure 1
Flow Chart for the Pulp and Paper Industry

Table 2: Breakdown of Planning, Financial and Mill Construction Costs at 1966/67 Cost Levels*

Component	Amount
	Thousand U.S. dollars
A. PLANNING AND PREOPERATING COSTS	
Feasibility studies	56
ater supply testing and design	46
Forestry survey, wood sampling, etc.	370
Market survey	51
Product development testing	139
Project management (owner)	555
Preoperating costs	1711
Executive management	231
Total Planning and preoperating costs	3159
B. FINANCIAL COSTS	
Bond issue	648
Interest during construction	1572
	2220
C. MILL CONSTRUCTION COSTS	
Direct construction costs	
Woodroom and chip handling	2479
Digesting	3885
Brown stock	4116
Bleaching	4209
ClO_2 manufacture	740
Pulp drying	7030
Recovery and precipitator	5550
Evaporators	786
Power boiler	1758
Recausticizing	2498
Mill water supply and treatment	1572
Site preparation	203
Waste disposal	518
General services	2238
Nonprocess buildings	1434
Fuel storage and handling	148
Spare parts	444
Total direct construction costs	39 609
Indirect construction costs	
Construction camp	1406
Field expenses	1110
Field engineering	694
Engineering design	3422
Total indirect construction costs	6632
Total mill construction costs	46 241

*Adapted from the FAO 'Guide for Planning Pulp & Paper Enterprizes'

Table 3: Annual Fixed Production Costs, 1968 to 1972 *

	1968	1969	1970	1971	1972
	Thousand U.S. dollars				
Wages and salaries	2498	2655	2831	3016	3210
Maintenance	1804	1859	1924	1989	2054
Supplies	356	362	367	374	381
Administration					
Fuel	93	93	93	93	93
Insurance	101	101	101	101	101
Taxes	1110	1110	1110	1110	1110
Power	462	462	462	462	462
Other	400	439	486	533	586
	7063	7333	7642	7964	8301
Depreciation on items A, B and C as shown in Table 3	2616	2651	2686	2723	2760
	9679	9984	10328	10687	11061
Startup charges and alterations	1110	370	--	--	--
Total	10789	10354	10328	10687	11061

*Adapted from the FAO 'Guide for Planning Pulp & Paper Enterprizes'.

Table 4: Pulping Processes*

Glass	Mechanical	Wastepaper	Chemi-mechanical	Semi-mechanical	High-yield bisulphite	Chemical
Typical processes	Stone groundwood Chip refiner groundwood	Repulping wastepaper	Great Northern Storabrite Cold soda ALB Semicell	Neutral sulphite semi-chemical = NSSC	Arbiso	Sulphite Magnefite Sulphate (kraft) Sivola Stora Kopparberg
Yield of fibre (%)	90-95	65-90	80-90	60-85	65-75	43-55
Fibrizing power, (kWh per ton)	700-1800	Low	700-1400	300-700	200-400	None
Preferred species	Conifers (poplars, eucalypts, other hardwoods) Wood residues	Mixed wastepaper Segregated wastepaper Old corrugated boxes Kraft waste Old newspaper	Hardwoods (softwoods)	Hardwoods (softwoods)	Conifers	Almost any
Pulping chemicals	None	Alkali detergents	Sodium sulphite *or* Sodium hydroxide	Sodium sulphite *or* Ammonium sulphite	Sodium bisulphite	Calcium, magnesium sodium or ammonium bisulphites *plus* sulphurous acid *or* sodium hydroxide *plus* sodium sulphide
Bleaching Chemicals	None *or* hydrosulphite	None *or* hydrosulphite	None *or* hydrosulphite	None *or* hypochlorite		Chlorine Sodium hydroxide and hypochlorite with or without chlorine dioxide or peroxide
Uses	Newsprint Printing papers Writing papers Tissue Creped papers Containerboard Moulded pulp products	Container board Paperboard Newsprint Book paper Construction paper Moulded pulp products	Newsprint Printing and writing papers Coating base	Corrugating Printing and writing papers Coating base	Newsprint Printing papers	All papers and paperboards

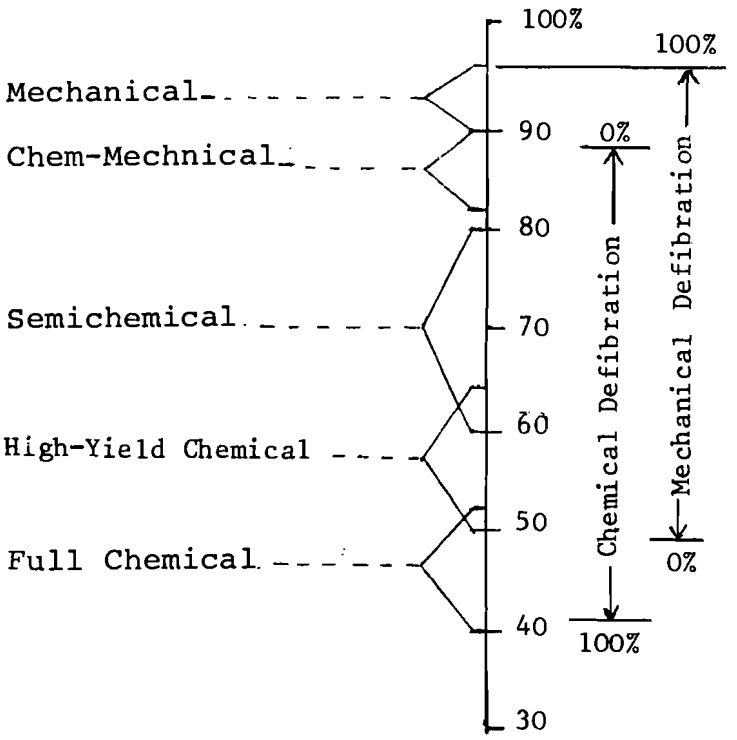
*Adapted from FAO 'Guide for Planning' and 'Chemical and Process Technology Encyclopedia'.

As one can see from this flow chart a great deal of material regarding pulp manufacture has only been lightly touched, however it is not expedient to deal at length with every aspect of this industry in this report. If the reader requires or wishes additional detailed information, then attention should be directed towards the works referenced by this report. The sole exception to this will be a discussion on the 'Full Chemical' processes. This exception is made due to the increasing importance of full chemical pulps.

Full chemical pulps are achieved basically by 3 methods; the soda process, the Kraft process, and the sulfite process. At this time the soda process has largely been superseded by the Kraft process and is used mainly for pulping wastepaper, straws and the like. The Kraft processes are applicable to nearly all species of wood, and effective means of recovering spent cooking chemicals for recycling have been developed. Also, this process is responsible for much of the increase of 'Full Chemical' pulps to other methods of pulping. The ratio of bleached and unbleached Kraft pulp to total pulp produced is increasing steadily. Listed last, but of enormous importance is the sulfite process. From this process comes newsprint and liner stock. The sulfite process differs from the Kraft process in that while the Kraft process is highly alkaline, the sulfite process is acidic in nature.[8]

Pulp yields for the various processes are shown in Figure 2. These are characterizations for unbleached pulp yield, and are not significantly different with respect to bleached pulp yields.[9]

Figure 2



Unbleached Pulp Yields*

*Chemical and Process Technology Encyclopedia

Note, the relatively low yield for the full chemical processes. However, demand for high quality paper which the full chemical method achieves, places an ever increasing importance on that process. See, also, Table 2 processes breakdowns and inputs.

5. Paper Manufacture

Only scant attention will be paid to the papermaking aspect as it is relatively non-water intensive, in the flow-through sense, and is very complicated in terms of processes used and timing for end-product output. Also, this report focuses on pollution of water and not necessarily on paper outputs, of even, for that matter, air pollution--another significant output of the pulp and paper industry. The attention paid to this production aspect is due to the tendency towards integration of the pulping and papermaking functions into one production facility. However, in as much as papers remains the 'Raison d'être' of this industry, some discussion about paper manufacture seems appropriate.

The invention of paper by Ts'ai Lun, a member of the Imperial Guard and Privy Councillor, was announced to the Emperor of China in 105 A.D. It was a unique event. Papyrus, a laminate, had been used as a writing base for at least two millennia in Egypt. Elsewhere parchment, cloth, wood, clay and stone had been used for written records for many centuries. In China itself, wood, bamboo, and cloth, including silk, were the main writing materials. As paper became available, the other materials were gradually displaced.

The uniqueness of the event is attested by its slow communication to other parts of the world: 500 years to reach Japan, 600 years to reach Samarkand and the Arab world, and 1,000 years before paper was made in Europe.

The invention consisted of a combination of a number of separate concepts, and in fundamentals there is no great gap between the first paper-making and current practice. There are six elementary steps involved in making paper:

1. A fibrous raw material is pulped, that is, it is so treated mechanically, chemically or by some combination of these, that the individual fibers are more or less completely separated.
2. The fibers are dispersed as a dilute suspension in water.
3. The fibres are filtered from the suspension through a sieve or screen, a "mould", or "wire", in such a fashion as to make a uniform layer of drained pulp.
4. The screen is separated from the paper, an operation called "couching", in such a way as to leave the wet, and therefore fragile sheet unwrinkled and undisturbed.
5. The couched paper is placed in contact with a woven cloth, a "felt", and pressed to remove excess water.
6. The moist paper is removed from the felt and dried.

The steps in making paper may be represented by the process flow block diagram in Figure 3.

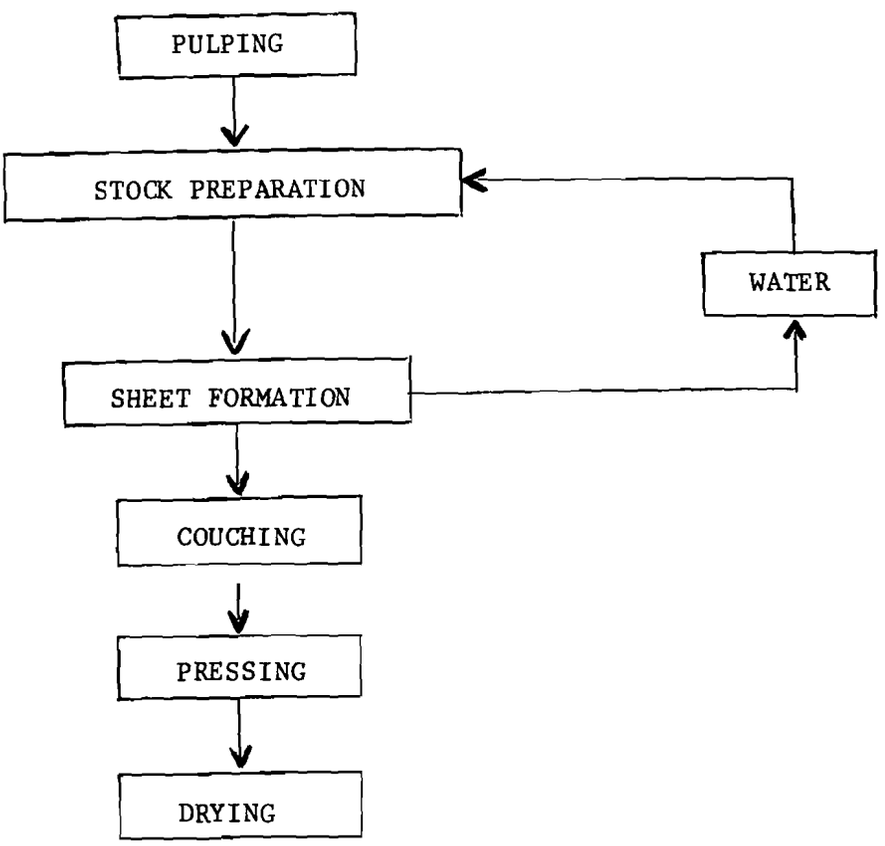


Figure 3

Six Step Fow Block Diagram

Paper Manufacturing Process

Papers are most often classified by function into two broad groups: "cultural" papers, which include newsprint, magazines, books, and other printing and writing papers, and "industrial" papers, and paper board, including bag, sack and wrapping papers, corrugated and folding box papers and paperboard, foodboard, and structural papers such as building and wallpapers. Tissue, towel and similar crepe papers, moulded pulp product, such as egg, fruit and plant containers, metallized and plastic-coated papers and capacitor papers also fall into the class of industrial papers. A new product of paper machines with many of the properties of cloth fabric, the nonwoven textiles, sometimes called "disposables", also belong in the industrial paper group.[10]

6. Water Pollution

What are the major water pollution problems and how are they being solved?

Needless to say that pollution is an undesired outcome that, until recently, has been an inevitable social cost of producing pulp and paper. Also, it should be noted that the pulp and paper industry was one of the largest polluters of the environment, and that fortunately this situation has changed for the better.[11]

Water pollution can have two main effects:

1) contamination, that is effluent discharge that renders water dangerous to humans; and

2) pollution of air and water such as to render the environment aesthetically less pleasing, and may or may not be toxic to aquatic life.[12]

It is in the second category that pollution from the pulp paper industry mainly falls.[13]

Control of this pollution has taken place in a step-wise fashion, involving several disparate factors. First, as the industry evolved technologically, environmental concern and economies realized in reclamation of processing chemicals,

grew apace. Hence, despite an industry growth rate of about 5% per year, pollution of air and water such as to render the environment less pleasing, has been steadily decreasng. Second, the design and installation of conventional abatement equipment has greatly improved the position of older pulp and paper mills vis-a-vis the environment. Third, the incorporation of provision for maximum water recirculation and fiber recovery, followed by effluent treatment, as a fundamental part of the design of all new mills. And, finally, the closing down of older mills if they cannot phase out pulping processes that cause gross pollution and/or if their technological age is such as to defeat pollution abatement solutions.[14]

A list of pollutants, their sources, and the methods of abatement are shown in Table 5.[15]

Table 5

Pollution from the Pulp and Paper Industry Sources, Types, and Methods of Abatement

Source	Nature of Pollutant	Method of Abatement
Wood room debarkers and screens	Bark, bark fines passing through screens, grit from logs	Bark pressed and burned in bark boiler, ash and grit collected for land disposal fines removed in primary clarifyier
Mechanical pulping	Fiber fines, grit from stones, BOD (largeinstallations)	Fines removed in primary clarifier, grit settled out in settling chambers, BOD reduced through biological treatment
Chemical pulping (or cooking) and washing	Fiber fines, soluble organics (BOD), erude soaps, color bodies, soluble inorganics	Fines removed by primary clarifier, clarified effluent treated biologically to reduce BOD by means of aerated lagoons or some modification of activated sludge process, erude soaps collected during liquor evaporation and shipped as tall oil or burned, concentrations of color bodies and soluble inorganics reduced by dilution in receiving waters
Screening	Knots, shives, coarse fiber, soluble organies (BOD)	Refined, cleaned, and returned to system; water recirculated; dirt, shives, and fines rejected are then removed in primary clarifier, BOD reduced by biological treatment
Bleaching	Fiber fines, soluble organics (BOD), color bodies, soluble inorganics	Fiber fines removed in primary clarifier or settling lagoon, BOD of clarified effluent reduced by biological treatment (lagoons, activated sludge process, or modification), color bodies and soluble inorganics reduced in concentration by dilution
Paper manufacturing	Fiber fines, clays and other minerals	Filler clays and fiber fines removed in primary clarifier -- may require special chemical treatment with alum, lime, or ferrie compounds
Coating (on or off machine)	Coating minerals, binders such as starch have a BOD	Primary clarification, employed to remove coating minerals in suspension, may require special treatment; BOD of clarified effluent reduced in biological treatment

From 'Industrial Pollution Control Handbook'

7. Analysis of Water Demand and Waste Water Discharge

Unfortunately, the material researched did not cover product mix, production process with regard to time, and integration of the manufacturing elements (reference was made to a tendency towards aggregation, however, no numbers were mentioned). Also, beyond the mention of old mills, nothing was given in terms of percentages regarding that portion as a total of the industry. Answers to these questions become important if one seeks to model water demand or for that matter the modelling of any of the inputs associated with pulp and paper manufacture

Furthermore, the section which dealt with size and importance of the pulp and paper industry referred to annual rates of growth for various regions (i.e., Latin America 17% annual increase in paper production). What is not stated is that fully 95% of world production is in the developed world.[16] In other words 17% of 5% compared to 5% of 95% means that the 5% growth rate of the developed countries outstrips the growth rate in developing countries by more than 4 to 1 with respect to total world production. At their present growth rate, Latin America will have less and less of this total world production as time goes on. One hopes that the argument raised by the developing countries, that environmental controls should not be used until their industries have acquired substantial percentages of world production, will not be used with respect to such a potentially large polluter of the environment as the pulp and paper industry.

Footnotes

1. Industrial Pollution Control Handbook, McGraw-Hill Book Company, New York, pp. 18-1.

2. Ibid, pp. 18-1, 18-2.

3. Encyclopaedia Britannica, Vol. 17 , p. 280.

4. Statistical Abstract of the United States 1976 U.S. Department of Commerce, Bureau of the Census, pp. 5 and 685.

5. Handbook of tables for Applied Engineering Science Second Edition, CRC press, Cleveland, Ohio, p. 741.

6. Guide for Planning Pulp and Paper Enterprizes (FAO Forestry and Forest Products Studies, No. 18) 1974 U.N. publication.

7. Ibid

8. Chemical and Process Technology Encyclopaedia, McGraw-Hill Book Company, New York, p. 935.

9. Ibid, p., 935.

10. Encyclopaedia Britannica, Vol. 17.

11. Industrial Pollution Control Handbook, McGraw-Hill Book Company, New York, p. 18-2.

12. Ibid, p. 18-2.

13. Ibid, p. 18-3.

14. Ibid, pp. 18-1, 18-2.

15. Ibid, p. 18-9.

16. UNCTAD Handbook of International Trade and Development 1976.

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