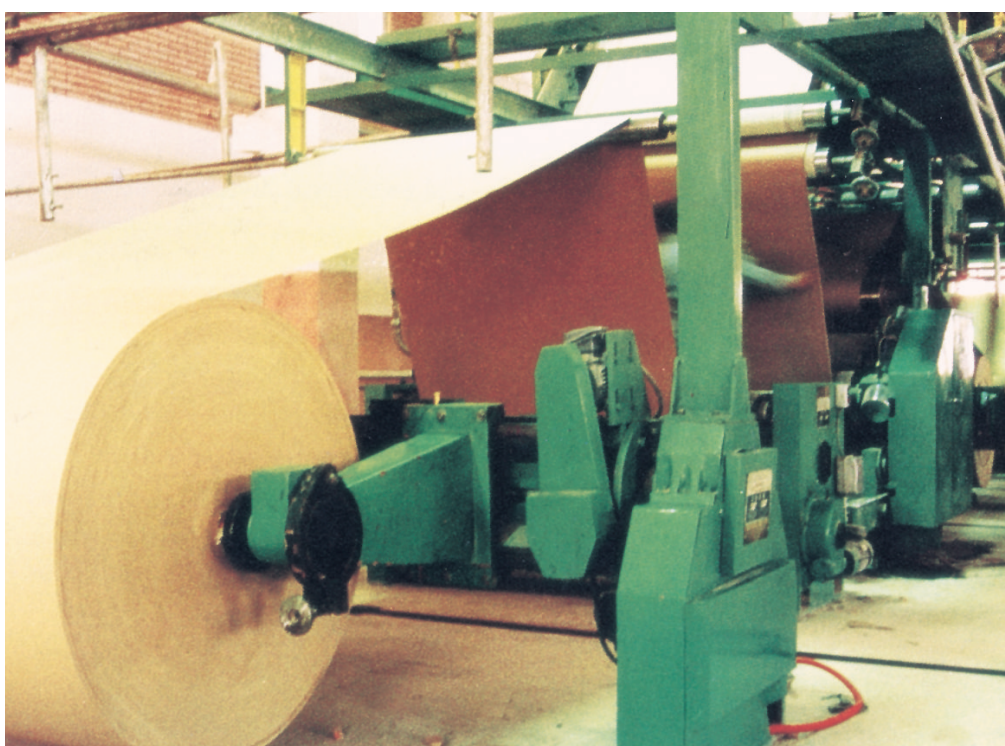


Ministry of State for Environmental Affairs

Egyptian Environmental Affairs Agency (EEAA)

Egyptian Pollution Abatement Project (EPAP)

Self Monitoring Manual Pulp and Paper Industry



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GLOSSARY OF TERMS AND ABBREVIATIONS

I – TERMS OF PULP&PAPER INDUSTRY

Air dry: Air dry ton of pulp (Adt) meaning dry solids content of 90 %.

Bleaching: the process of brightening the fiber by removal of the colored substance or by decolorizing it.

Broke: Paper that has been discarded anywhere in the process of manufacture.

Brownstock: the suspension of unbleached pulp.

Chemical pulp: Fibrous material obtained by removal from the raw material by chemical treatment (cooking, delignification, bleaching).

Consistency: The weight percent of air-dry (or oven dry) fibrous material in a stock or stock suspension. Low consistency (3% - 5%, LC), medium consistency (10% - 15%, MC) and high consistency (30% - 50%, HC) are distinguished.

Cross media effects; Possible shift of environmental pressure from one environmental media to the other.

Deinking: The process of removing ink from printed wastepaper, but also involving general removal of other undesirable materials.

Dispersing: Mechanical treatment of wastepaper fibers to disperse ink particles.

Dry end: Part of the papermaking process after formation of the paper web.

Fillers: papermaking additives, usually mineral clays or calcium carbonates.

Fines: Small particle sized material in papermaking usually defined as material below 75 microns.

Furnish: The mixture of various materials that are blended in the stock suspension from which paper or board is made. The main constituents are the fibrous material (pulp), fillers, sizing agents, wet-strength or other additives, and dyes.

Grammage: The real mass of the paper/board, usually expressed as g/m².

Head box: Pulp feed to the paper machine starts here.

Integrated production: An installation in which the production of paper and/or board is directly connected with the production of pulp.

Kappa number: A measure of residual lignin content in unbleached pulp, determined after pulping and prior to bleaching. The lower the Kappa number the less associated lignin.

Kraft pulp: Chemical pulp that has been manufactured using sodium sulfate as the main cooking chemical.

Lignin: This is the binding substance in natural fibers and is a complex organic polymer with an irregular structure.

Mechanical pulp: Papermaking pulp made entirely by mechanical means from various raw materials i.e. by grinding wood against an abrasive or by processing wood chips or sawdust through a refiner.

MF resin: Melamine formaldehyde resin.

Non-Integrated Production: An installation in which the production of paper and/or board is not directly connected with the production of pulp.

Paper: Sheet of fibers with a number of added chemicals. According to the basic weight it can be distinguished: Paper $< 150 \text{ g/m}^2$ < paper-board (or board) $< 250 \text{ g/m}^2$ < cardboard.

Pitch: A resinous material in virgin pulps.

Pulping: The process of converting raw fiber or recycled fiber to a pulp usable in papermaking with minimal further treatment.

Refining: Process of mechanically treating fibers to develop strength.

Save-all: An apparatus used for reclaiming fibers and fillers from white water. It usually operates on a filtration, sedimentation, flocculation, or flotation principle.

Soap: The product of reaction between the alkali in kraft pulping liquor and fatty acid portions of the wood, which precipitate out when water is evaporated from the spent pulping liquor.

Specific water consumption: The amount of fresh water consumed during production (surface water, ground water) that is taken out from external resources. This fresh water demand is related to air-dry net production and is expressed as m^3/t .

Stickies: Materials that stick together; adhesive contaminants in recovered paper.

Stock: The mixed suspension of fiber and other materials used to form the paper.

Sulfite pulp: Chemical pulp where various sulfites or bisulfites are used as main cooking chemical.

Thermo-mechanical pulp: Papermaking pulp made entirely by mechanical means from various raw materials, but usually wood. In the thermo-mechanical pulping process the raw material is subjected to thermal pre-treatment.

UF resin: Urea formaldehyde resin.

Recycled fiber pulp: Fibrous material that has already passed through paper and/or board production.

Wet-end: Part of the papermaking process prior to formation of the paper web.

White water: A general term for all waters of a paper mill that have been separated from the stock or pulp suspension, either on the paper machine or accessory equipment, such as thickeners, washers, save-alls, and from pulp grinders. It carries a certain amount of fiber and may contain varying amounts of fillers and dyestuffs.

Wood-containing paper and/or board: Paper and board having considerable part of non-cellulosic compounds (more than 5%) as an essential constituent of its fiber composition.

Wood free paper and/or board: Paper and board having in principle only chemical pulp in its fiber composition; (less than 5% non-cellulosic compounds).

Yankee cylinder: Large single cylinder used mainly to dry tissue/towels.

Yield: The amount of useful fiber after pulping and/or bleaching or deinking expressed as a percentage of the raw fiber.

II - ABBREVIATIONS

Adt: Air dry metric ton of pulp meaning dry solids content of 90 %. Note that an air-dry ton of paper is defined as paper with 6% moisture content.

AOX: Adsorbable Organic Halides measured according to the ISO 9562: 1998 standard methods for wastewater.

BOD5/BOD7: Biological Oxygen Demand indicating the amount of biodegradable organic matter in the wastewater assessed using a standard 5 day or 7 day test.

COD: Chemical oxygen demand indicating the amount of chemically oxidisable organic matter in the wastewater (normally referring to analysis with dichromate oxidation)

CTMP: Chemi-thermo-mechanical pulp

DAF: Dissolved Air Flotation

D/C: Bleaching stage with chlorine dioxide and chlorine where chlorine dioxide dominates over chlorine.

DIP: Deinked pulp – pulp produced from recovered printing paper, e.g. newsprint, through de-inking process.

DS: Dry solids

ECF: Elemental Chlorine Free (bleaching).

EDTA: Ethyl Diamine Tetra Acetic acid, complexing agent.

E/O: Extraction bleaching stage using sodium hydroxide with subsequent addition of gaseous oxygen.

EOP: Extraction bleaching stage using sodium hydroxide with subsequent addition of oxygen and hydrogen peroxide solution.

E/P: Extraction bleaching stage using sodium hydroxide with subsequent addition of hydrogen peroxide solution.

ESP: Electrostatic precipitator.

HC: High consistency - pulp concentration in the interval 30 - 50% dry solid content.

H₂O₂: Hydrogen peroxide

% ISO: Brightness unit according to ISO, the International Organization for Standardization.

LC: Low consistency - pulp concentration in the interval 3 - 5% dry solid content.

LWC: Lightweight coated paper

MC: Medium consistency - pulp concentration in the interval 8 – 15% dry solid content

Mg: Magnesium.

MLSS: Mixed Liquor Suspended Solids.

MWC: Medium weight coated paper.

NCG: Non-condensable gases referring to malodorous gases of chemical pulping.

N_{dg}: Normal dry gas related to standard conditions.

No_x: The sum of nitrogen oxide (NO) and nitrogen dioxide (NO₂) expressed as NO₂.

O: oxygen-bleaching stage

P: Alkaline bleaching stage with hydrogen peroxide (H₂O₂) as liquid

Q Acid bleaching stage where chelating agent EDTA or DTPA has been used for removal of metals.

RCF: Recycled fiber(s); pulp obtained from recovered paper processing.

S: 1) Sulfur 2) Acid bleaching stage with sodium hydrosulphite (NaHSO₃).

SO₂: Sulfur dioxide.

SS: Suspended solids.

TCF: Totally chlorine free (bleaching).

TRS: Total reduced sulfur meaning the sum of the reduced malodorous sulfur compounds generated in the pulping process: hydrogen sulfide, methyl mercaptan, dimethylsulphide and dimethyldisulphide expressed as sulfur.

TSS: Total suspended solids (in wastewater).

TSP: Total solid particulates (in flue gases), dust.

VOC: Volatile Organic compounds.

WWTP: Wastewater treatment plant.

Z: Ozone bleaching stage using gaseous ozone (O₃)

1. INTRODUCTION

The Egyptian Pollution Abatement Project (EPAP) sponsored by FINIDA has assigned Finish and Egyptian consultants for the task of developing Sector specific inspection and monitoring guidelines. This task is based on a previous collaboration between FINIDA and EPAP that resulted in the development of four Inspection Guidelines:

- Fundamentals and Background Manual that provides basic information about air pollution, wastewater characteristics, solid waste, hazardous materials and wastes and work environment.
- Guidelines for Inspectorate Management that discusses the strategy, objectives and tasks of the Inspectorate management.
- Guidelines for Team Leaders that identifies the team leader responsibilities and tasks.
- Guidelines for Inspectors that presents a methodology for performing all types of inspection. Tasks during the various phases of planning, performing field inspection, report preparation and follow-up are discussed. Several checklists are included.

The three guidelines were later summarized into one that will be referred to as the Inspection Guidelines. A General Inspection Manual, GIM, is being developed to cover the aspects common to all sectors.

On the other hand, EPAP realized the need to introduce the concept of self-monitoring, as it provides useful information to the plant's management on the production efficiency as well as the environmental status. Self-monitoring should cover, as a minimum, the monitoring of the releases to the environment including emissions to air, wastewater, solid waste and hazardous waste. A comprehensive self-monitoring plan may cover process parameters that would affect the environmental impacts. Such plan would assist the management to identify sources of waste, prevent pollution at the source, reduce emissions, and achieve economic benefits.

Therefore, a Self-Monitoring Guidebook was also developed to present the industrial community, the consultants, and government officials with the general principles and both managerial and technical aspects to be followed for self-monitoring. The textile industry was chosen as a case study for implementing and testing the manual and a self-monitoring manual for this industry was developed.

1.1 Preface

The developed manuals were tested through a number of training programs that targeted RBOs and EMUs. The inspectors involved in the training used these manuals to inspect a number of industrial facilities. Feedback from the concerned parties led to the improvement of these manuals and their continuous update. There was clearly a need for sector-specific guidelines, and EPAP took the initiative to develop such manuals. Five sectors were chosen:

- Food Industry with specific reference to the five sub-sectors of Dairy products, Vegetables and Fruit processing, Grain Milling, Carbonated Beverages and Confectionery.
- Pulp and Paper Industry
- Metallurgical Industry with specific reference to the two sub-sectors of Iron and Steel and Aluminum.
- Engineering Industry with specific reference to Motor Vehicles Assembly and Fabricated Metals industries.
- Textile Industry.

1.1.1. Project objectives

The project aims at the development of sector-specific guidelines for inspection and monitoring to be used by inspectors and plant personnel respectively. These manuals are meant to be simplified but without abstention of any information necessary to the targeted users. Flowcharts, tables and highlighted notes are used for easy representation of information.

With respect to the pulp and paper industry, two distinct manuals were developed, one for inspection and the other for self-monitoring. Description of the industry, pollution aspects and relevant environmental laws will be similar for both manuals. Each manual will be, as much as possible a stand-alone with occasional cross-reference to the General Guidelines previously developed to avoid undue repetitions.

1.1.2 Organization of the manual

The self-monitoring manual for the pulp and paper industry includes eleven chapters. The first chapter represents an introduction to the whole project and to the specific sub-sector of the industry. Chapters 2 to 5 deal with the pulp and paper industry and its environmental impacts.

The description of the industry in Chapter two includes the inputs and outputs, a description of the different production lines with their specific inputs and outputs. In addition, it also includes a brief description of the service and auxiliary units that could be present at the industrial establishment with their potential sources of pollution and the various emissions, effluents and solid wastes generated from the different processes.

Chapter 3 describes the environmental and health impacts of the various pollutants whereas Chapter 4 gives a summary of the articles in the Egyptian environmental laws relevant to the pulp and paper industry. Chapter 5

gives examples of pollution abatement techniques and measures applicable to the pulp and paper industry.

The information and steps needed to establish of a self-monitoring system are detailed in chapter 6-11 inclusive. A reasonably detailed introduction to the definition, objectives, benefits of self-monitoring are presented in Chapter 6, in addition to the link between self-monitoring and each of environmental management system and cleaner production. Chapter 7 deals with the aspects of planning of self-monitoring. Monitoring of raw materials is discussed in Chapter 8, while operation control aspects are discussed in Chapter 9. Environmental monitoring is described in Chapter 10. Chapter 11 is dealing with data collection, data processing and data usage.

1.2 Introduction to the pulp and paper industry

The Pulp and Paper Industry is one of the growing industries all over the world, including Egypt. In 1998, the annual production of paper and paper products in Egypt was about 500,000 tons. Additional projects with production capacities of 240,000 tons were being established

1.2.1 Egyptian SIC code for the pulp and paper industry

The Standard Industrial Classification (SIC) code for the pulp and paper industry is 34 and the paper products industries have a sub-sector code of 19.

1.2.2 Industry size distribution

This industry sector has been previously surveyed in 1998 through the Egyptian Pollution Abatement Project (EPAP). The total production of paper and paper products is about 500,000 tons. Chemical pulp is mainly produced in three factories (Kous, Edfu and Rakta). Most of the paper and paperboard production is based mainly on secondary fibers, as well as imported fibers. Local pulp production includes 150,000 tons utilizing sugar cane waste (bagasse) and 25,000 tons from rice straw. The environmental impact due to bagasse pulp production is more controlled compared to rice straw pulping, due to the different chemical properties of the effluents. However, research activities and/or projects are being considered in order to improve the economic and environmental impacts of this industry.

The following table summarizes the production data as presented in other EPAP's reports.

Table .1 Annual Pulp & Paper Production

Sector & Company	Products	Annual Production (1000 tons)
<u>Public Sector:</u>		
Rakta	Paper	40
	Board	15
	Rice Straw Pulp	30
National Paper	Printing Paper	10
	Kraft/sack paper	22
	Wrapping/Packing	9
	Board	7
Simo	Board	21
Kous	News-printing Paper	120
Edfu	Bagasse Pulp	25
<u>Private Sector:</u>	Wrapping/packing/Board	160
	Tissue	30
<u>Total</u>	Pulp	55
	Paper Products	434

2. DESCRIPTION OF THE INDUSTRY

Paper is essentially a sheet of cellulose fibers with a number of added constituents to affect the quality of the sheet and its fitness for intended end use. In addition to the differences in the production processes, the two terms of paper and board generally refer to the weight of the product sheet (grammage) with paper ranging up to about 150 g/m² and a heavier sheet regarded as board (paperboard).

In the pulping process the raw cellulose-bearing material is broken down into its individual fibers. Wood is the main raw material but straw, bagasse, cotton and other cellulose-bearing material can be used.

In chemical pulping, chemicals are used to dissolve the lignin and free the fibers. The lignin and many other organic substances are thus put into solution from which the chemicals and the energy content of the lignin and other organics may be recovered. In mechanical pulping processes, mechanical shear forces are used to pull the fibers apart and the majority of the lignin remains with the fibers although there is still dissolution of some organics.

The production of chemical pulp is the major source of environmental impacts in the pulp and paper industry. It could also be noted that the significance of raw materials preparation has been increased as source of environmental impacts. Pulps produced in different ways have different properties, which make them suited to particular products. Most pulp is produced for the purpose of subsequent manufacture of paper or paperboard. Some is destined for other uses such as thick fiberboard or products manufactured from dissolved cellulose.

Paper produced by the use of recovered paper as fiber source will involve some cleaning of contaminants prior to use, and may involve de-inking depending upon the quality of material recycled and the requirements of the end product. The fibers are reusable for a number of times depending on the quality of the recycled material and the purpose of the end product.

Paper is manufactured by applying a watery suspension of cellulose fibers to a screen, which allows the water to drain, and leaves the fibrous particles behind a sheet. The production of this industry covers a range of products that may include newsprint, packaging paper boards, coated and non-coated printing and writing papers, liner and fluting, tissue, packaging papers, and specialty papers. Each of these categories demands specific properties of the product and the most appropriate manufacturing route to these products may differ substantially. Thus, pulp and paper mills have a wide range of configurations, depending on the specifications of the final product, fiber raw materials and the applied techniques. In general, pulp and paper mills can be either integrated or non-integrated. Integrated mills comprise both pulp and paper production processes. While, non-integrated mills may produce either pulp or paper products.

2.1 Inputs to industry

2.1.1 Raw Materials, Chemicals and Energy

Fibre raw materials

Internationally, wood is the main fiber raw material for the Pulp and Paper industry. In Egypt, bagasse, rice straw and recycled paper are the main fiber raw materials being used.

a) Wood fibres: This includes those coming from natural forest (hardwoods, softwoods), forest plantations and residues from mechanical industry (mainly sawn mills). The most commonly used furnish material is wood.

Wood, as a raw fiber material is not used in Egypt. However, some plants may import bleached or unbleached pulps that are produced from wood fibers.

b) Non-wood fibres: This can be subdivided as follows:

In Egypt, bagasse (a by-product of sugar cane industry) is the main fiber raw material for pulp production. Also, rice straw is currently used as furnish for pulp production. Rice straw is available at a minimal cost. However, the economic effectiveness is relatively low due to unavailability of proven technology for chemical recovery, due to the silica content of the resulted black liquor.

c) Recycled fibres (Secondary fibres): This comprises a common furnish constituent in Egypt. Secondary fibres consist of pre-consumer fibres (e.g. mill waste fibres) and post-consumer fibre. Post-consumer fibre sources are diverse, but the most common are newsprint and corrugated boxes. Secondary fibres sources are seldom used as feedstock for high quality or grade paper products. Contaminants e.g. inks and paper colours are often present, so available decontamination technologies may be used.

Chemicals:

Chemicals are mainly used in the pulping processes as well as other complementary processes e.g. bleaching, coating and wastewater treatment. The commonly used chemicals and the consumption rates for the main pulping processes are herein presented. The consumption rates are based on the European data, because the databases for the mills in Egypt are not available.

Kraft Pulping: Typical chemicals and consumption [kg/t] for unbleached kraft pulp is in the range of NaOH: 10-20 and CaO: 5-10. On the other hand, the consumption [kg/t] of the main chemicals used in bleached pulp production is NaOH: 25-50, O₂: 5-25, NaClO₂: 20-50, H₂O₂: 2-30, MgSO₄: 0-3, SO₂: 2-10, CaO: 5-10.

Recovered Paper Recycling: Depending on the specific process, the chemicals may include: H₂O₂, NaOH, Na₂SiO₃. The consumption of chemicals in a typical mill

including de-inking process [kg/t stock] is Sodium hydroxide: 10 – 20, Sodium silicate: 20 – 30, Soap: 5 – 8, Talc: 10 – 15, Hydrogen peroxide: 5 – 25, Chelating agent: 2 – 3, Sodium dithionite: 6 – 10 and Sulphuric acid: 8 - 10

Paper and Board Production: The main chemicals being used may include Fillers, Sizing agents, Dyes, pigments and others.

Energy:

The pulp and paper industry is generally regarded as energy intensive industry. Some processes like paper making consume energy while, chemical-pulping process can produce excess energy from the spent cooking liquor. In modern pulping processes the cooking liquor is used as a fuel in recovery boiler to generate steam. Often, the residuals coming with the raw material and the wastes from the material handling and chipping are also used as a fuel. If integrated, the excess steam and electrical power can be used at the paper mill.

In recycled fibre processing, the separation from the base (waste paper) into fibres is already done, and hence less energy is needed for pulping. Instead, electric power is necessary for different pulp cleaning processes.

Energy needed for pulp and paper making processes is either produced on site (recovery boilers, auxiliary boilers) or imported as electric power. The share of fuels depends on the structure of the energy production.

2.1. 2 Water Characteristics and its Cycle

Paper and board mills commonly use large quantities of water. In Egypt, both groundwater and surface water is used. Depending on the paper grade, the water must be pre-treated in order to fulfil the requirements set for process water and boiler water.

Water has various basic applications in the paper industry as process water, cooling water and boiler feed water. Generally, process water is extensively recycled in the production process. All paper and board mills recycle drainage water of the wire section (white water). White water is recycled untreated as diluent to the mixing chest (short circuit) or it is reused after clarification in the fibre recovery unit at specific locations in the process where higher water quality requirements are to be met. Excess flow from the fibre recovery unit is discharged to keep the water balance and to purge unwanted substances that should not enter the approach flow of the paper machine.

The possible rate of recycling depends on the quality requirements of production and on the quality of the treated process/wastewater. In an integrated mill the wastewater from pulping and from papermaking are usually treated in one single treatment plant. In non-integrated pulp mills the market pulp has to be de-watered and dried. The water consumption varies considerably between different mills and it ranges between 15 and 100 m³/t. For example, the discharge of wastewater from unbleached kraft pulp mills ranges between 10-30 m³/ADT and 20-40 m³/ADT for bleached kraft pulp mills

2.1. 3 Storage and Handling of Raw Materials and Fuels

Raw fibre materials are usually transported to the mill and stored for the subsequent preparation processes. Minimising raw material storage should be a primary target in a pulp mill. Correct handling of fiber raw material is necessary when storing. Fluctuations in transport, harvesting, mill production, etc., may require using mill storage.

Bagasse has to be depithed as a preparatory step for pulp manufacturing. In Egypt, depithed bagasse is being produced in the sugar cane factories. Due to the seasonal harvesting of sugar cane, depithed bagasse has to be stocked for long periods. This is done under wet conditions. Rice straw is usually stocked in the form of dry piles. On the other hand, recovered papers (secondary fibres) are usually stocked in bales. In some cases it may be pre-sorted before they are sold to pulp and paper mill.

2.2 Production processes

The main processes of the production line can be divided into raw materials preparation, pulping operations and papermaking operations. Raw materials preparation is strongly related to the raw material base of the mill. Pulping operations can be subdivided into chemical pulping (kraft and sulphite), mechanical and chemi-mechanical pulping and recovered paper processing with or without de-inking. Energy and chemicals recovery systems are related to chemical pulping while; auxiliary boilers are related to papermaking processes.

Egypt: Pulp is generally produced using chemical kraft technique in case of bagasse, and soda pulping in case of rice straw.

Figures 1,2 show the sequence of the main processes in chemical and recovered paper pulping, respectively. The main processes for paper and paperboard production are illustrated in Figure 3.

2.2.1 Raw Materials Preparation

Bagasse: Bagasse has to be depithed as a preparatory step for pulp manufacturing. Prior to cooking process, bagasse is washed and de-watered.

Rice straw: The first step in the preparation is cutting and conveying the straw piles for primary cleaning. Vacuum is used in this step for dust removal. Then, furnish is then wet cleaned (washing process) and impurities are separated during this process.

Recovered paper: Recovered paper (secondary fibre) is normally delivered to the paper mill in the form of bales kept together by metal wires or straps. In some cases recovered paper is delivered as loose material in big containers or by bulk dumping. Usually secondary fibres are processed to remove contaminants before pulping. Contaminants may include adhesives, coating, polystyrene foam, dense plastic, polyethylene films, wet strength resins, and synthetic fibres.

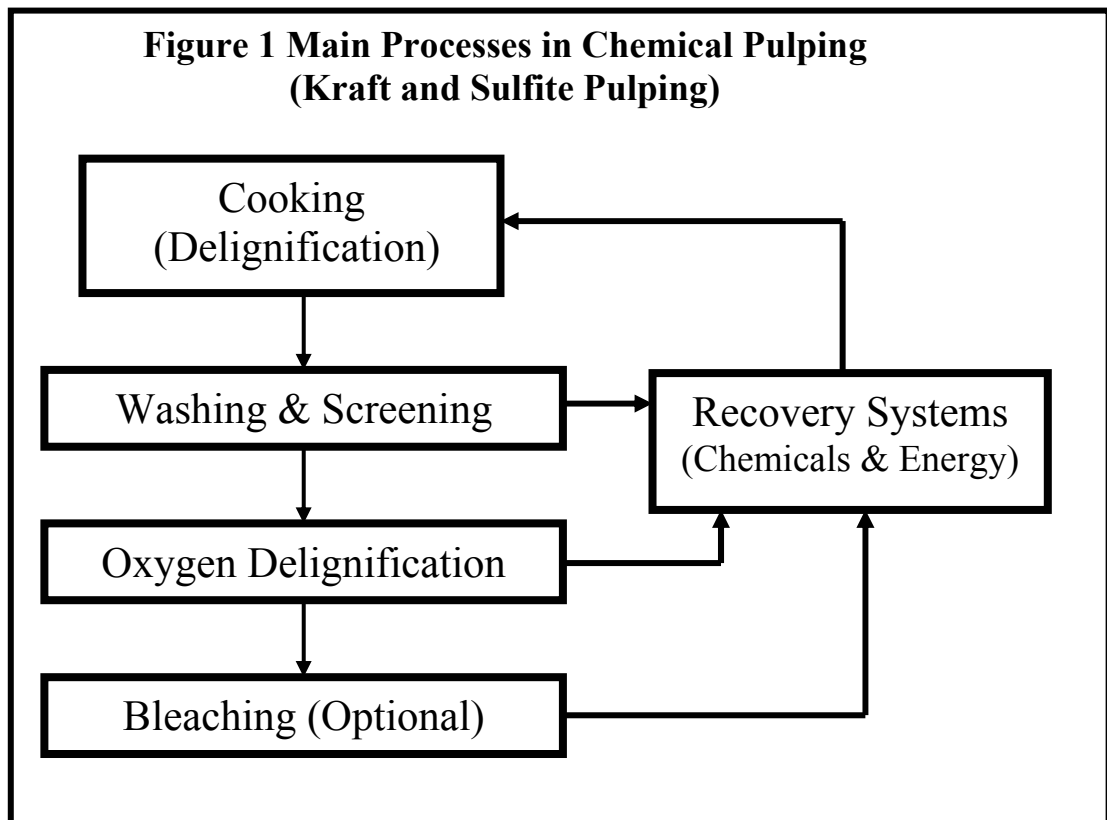
2.2.2 Pulping Operations

Pulping operations in the pulp and paper industry include chemical, chemi-mechanical and mechanical pulping. In addition, recovered paper is used for producing secondary pulps. Chemical pulping includes sulphite and sulphate (kraft) pulping processes. The sulphate (kraft) pulping is widely employed for wood and non-wood fiber materials e.g. bagasse.

Kraft (Sulfate) pulping

The term "sulfate" is derived from the make up chemical sodium sulfate, which is added in the recovery cycle to compensate for chemical losses. In the chemical pulping process the fibers are liberated as the lignin is removed by dissolving in the cooking chemical solution at a high temperature. In the kraft pulping, the active cooking chemicals (white liquor) are sodium hydroxide (NaOH) and sodium sulphide (Na_2S).

The main processes of a typical kraft pulping include cooking, washing and screening, oxygen delignification and bleaching. In kraft pulping, other delignification than cooking includes O_2 - delignification and bleaching, Figure 1.

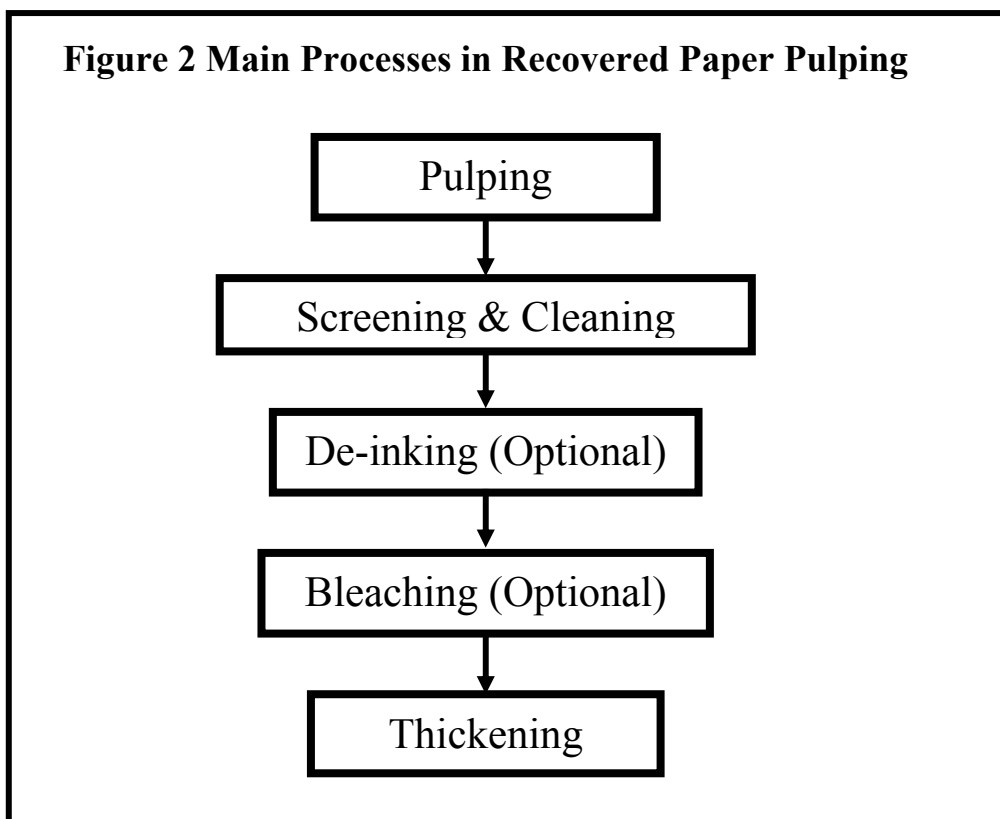


Recovered paper processing

Recovered fiber has become an indispensable raw material for the paper manufacturing industry. The recovered paper processing system varies according to the paper grade to be produced e.g. packaging paper, newsprint or tissue paper and the type of furnish used. Generally, recycled fiber (RCF) processes can be divided in two main categories:

- ☐ Processes with exclusively mechanical cleaning i.e. without de-inking.
- ☐ Processes with mechanical cleaning and de-inking.

Many different recovered paper-processing systems are being employed. All process systems are aiming at defibration, deflaking and removal of impurities. The typical stages of recycled fiber processing include re-pulping, mechanical removal of impurities, de-inking (optional), bleaching (optional) and cleaning and de-watering. See Figure 2.

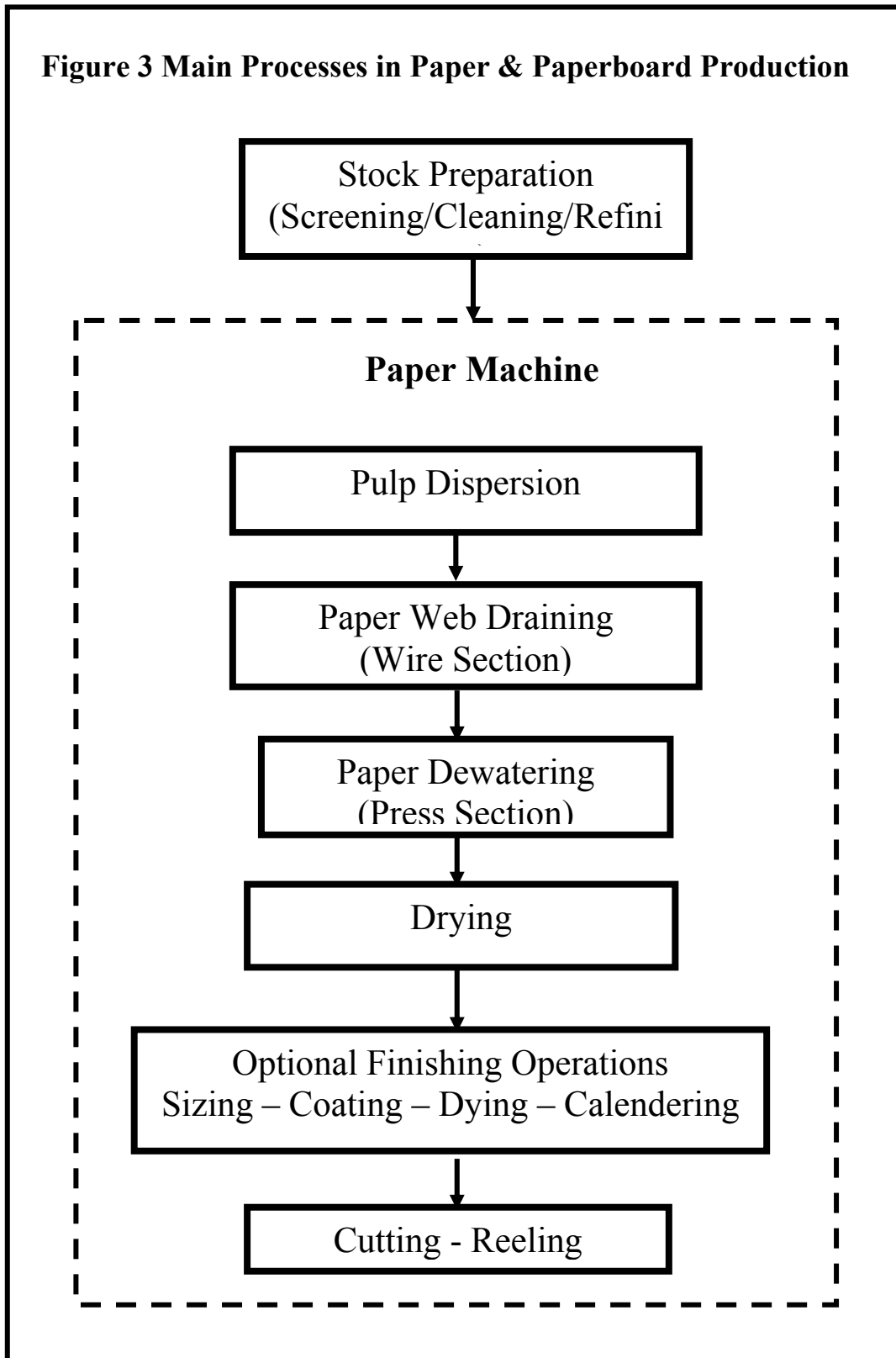


2.2.3 Papermaking and Related Processes

During the production of different paper grades, either virgin fibers (chemical or mechanical pulps) or recycled fibers are used as main raw materials. The composition of raw materials used for paper manufacturing (e.g. fibrous material, mineral fillers, coating) has a major effect on the product quality and the

environmental impact of the process. The basic units in a typical paper mill include stock preparation, approach flow system, and the paper or board machine. In addition, some other optional processes can exist e.g. calendars, coating, winders, re-winders and a roll wrapping station. See Figure (3).

Figure 3 Main Processes in Paper & Paperboard Production



Energy consumed for paper drying is primarily thermal energy or steam especially when using multiple cylinders drying. The dryer section is definitely the largest consumer of thermal energy on a paper machine as steam. A typical paper machine uses approximately 4 GJ of thermal energy per ton of paper produced as low-pressure steam.

2.3 Service units

Medium and large size mills will have some or all of the following service and auxiliary units. These units can be pollution sources and therefore should be inspected and monitored.

2.3.1 Boilers

The pulp making mills are characterized by the recovery systems e.g. recovery boilers. In paper making mills, boilers are essential. The gaseous emissions generated by boilers are typical of those from combustion processes. The exhaust gases from burning fuel oil (Mazout) or diesel oil (solar) contain primarily particulates (including heavy metals if they are present in significant concentrations in the fuel), sulfur and nitrogen oxides (SO_x and NO_x) and volatile organic compounds (VOCs). The concentration of these pollutants in the exhaust gases is a function of firing configuration (nozzle design, chimney height), operating practices and fuel composition. Gas-fired boilers generally produce negligible quantities of particulates and pollutants.

Wastewater is generated as blow-down purged from boilers to keep the concentration of dissolved salts at a level that prevents salt precipitation and consequently scale formation. The blow-down will be high in TDS. In the case of power plants, water is used for cooling the turbines and is also generated as steam condensate. The amount of wastewater generated depends on whether cooling is performed in open or closed cycle and on the recycling of steam condensate. Contamination may arise from lubricating and fuel oil.

2.3.2 Water Treatment Units

There are different types of water used in industry. Depending on the application and the water source, different treatment processes are applied.

a) Water Softening for medium hardness water: Calcium and magnesium ions are removed from hard water by cation exchange for sodium ions. The treated water has a hardness level of less than 1 ppm expressed as calcium carbonate.

b) Water softening for very high bicarbonate hardness: Water from wells and canals is pre-treated before softening. Water is treated first by the lime process, then by cation exchange. Currently the use of organic polyelectrolytes is replacing many of the traditional inorganic coagulant aid. Sludge precipitates are discharged to disposal sites whereas the overflowing water is fed to a sand filter followed by an activated carbon filter that removes any substances causing odor and taste.

c) Reverse Osmosis: Demineralization can also be performed by reverse osmosis. In this process water is forced through a semi-permeable membrane by applying pressure.

2.3.3 Laboratories

Laboratories may have an important role in the pulp and paper industry, as they can perform the following functions:

- ☐ Testing raw materials, chemicals, water, wastewater, ... etc.
- ☐ Quality control of the different products and comparing the findings with the standard specifications for raw materials and final products.

Chemicals used for testing could be hazardous. Proper handling and storage are required for compliance with environmental law.

2.3.4 Workshops and Garage

Large facilities have electrical and mechanical workshops for maintenance and repair purposes. Pollution in the garage area will depend upon the services offered. The presence of a gasoline or diesel station implies fuel storage in underground or over the ground tanks that require leak and spill control plans. Replacing lube oil implies discharge of spent oil to the sewer lines or selling it to recycling stations.

2.3.5 Storage Facilities

Raw fiber materials are usually stored in open areas under specific environmental conditions i.e. humidity. Paper and board products are stored in the form of reels or packaged according to customer requirements. In some cases, products may be stored under certain drying conditions to ensure specific moisture content. Chemicals are used extensively in the chemical pulping mills. Also, paper mills may use some chemicals for the finishing processes. In all cases, some of the chemicals could be hazardous and require special handling, storage and management procedures as required by law.

Fuel is used for the boilers and for the cars and delivery trucks. It is stored in underground or over ground tanks. The types of fuel usually used are fuel oil (Mazout), gas oil (solar), natural gas and gasoline.

2.3.6 Wastewater treatment plants

Pulp and paper mills discharge wastewater of high organic load, in addition to SS, which requires a wastewater treatment plant. From time to time peak loads may be discharged. They may be due to internal processes, to lack of control or incidental situations such as power collapse.

The potential pollution sources are:

- Sludge which represents a solid waste problem
- Treated water could represent a water pollution problem if not complying with relevant environmental laws

2.3.7 Restaurants, washrooms and housing complex

These facilities will generate domestic wastewater as well as domestic solid waste.

2.4 Emissions, effluents and solid wastes

In the following sections, estimates of pollution loads from the pulp and paper industry are presented. If not mentioned otherwise, the reference of the presented information and figures is:

“Environmental Impacts of Pulp and Paper Industry”, UNEP 1996, ISBN: 92-807-1589-5

These estimates are based on the monitoring databases for the European mills. Such data sources are not available for the Egyptian industry.

2.4.1 Air Emissions

Emissions to air from the pulp and paper industry to a large extent originate from the combustion of fuels. Transport vehicles, auxiliary boilers and recovery boilers related to chemical pulping processes all emit sulfur and nitrogen oxides, gases that acidify the atmosphere and in turn contribute to regional environmental impacts. Particulates as well as odorous compounds are pollutants, which have an environmental impact in the vicinity of pulp mills.

Kraft (sulfate) pulping: Most air emissions from a soda or sulfate pulping line originate from the recovery boiler, the limekiln and any auxiliary boiler. They consist of particulates; sulfur compounds derived from fuels, process chemicals in sulfate pulping and nitrogen oxides from combustion processes. In addition, foul smelling emissions (reduced sulfur compounds originating from the spent cooking liquor) arise from the fiber line washers, liquor tanks etc. in a sulfate pulping line. An overview of typical amounts is given in table below. The ranges reflect differences in the applied control measures.

Emission parameter	Value range (kg/t pulp)
Reduced sulphur compounds	0,005-10
Sulfure dioxide	0,01-10
Nitrogen oxides	0,02-5
particulates	0,02-12

Papermaking: Emissions to air from paper and board mills originate mainly from energy generation (steam and electricity) and not from the manufacturing process itself. Major pollutants in case of gas firing are CO₂ and NO_x, in case of oil or coal firing CO₂, NO_x, SO₂, dust and low concentrations of heavy metals. These emissions occur at the site of generation. Steam is normally generated at the paper mill in dedicated boilers, so the emissions occur at the site. In many cases, electricity is purchased from the grid, so the emissions occur at the power plant. The electricity/steam consumption ratio at paper mills enables the co-generation of heat and power (CHP). Many paper mills apply CHP and then all emissions to air associated with the energy consumption occur at the site.

In some special cases, emissions of organic carbon from the dryer section of the paper machine may occur. If so, they are caused by the use of additives (coating chemicals) or by not well designed water circuits and wastewater treatment plants

respectively but in most cases they are of negligible concern. Therefore, atmospheric emissions from paper mills are mainly related to energy generation. If incinerated, the solid wastes that include a high organic content (e.g. paper, rejects, de-inking sludge, and bio-sludge) may produce air emissions. Examples of measured emissions from incineration of different types of RCF paper mills residues are compiled in the following table, (Ref. Best Available Techniques in the Pulp and Paper Industry, July 2000).

Parameter	Unit	Average values Rejects from a RCF Packaging mill (Without de-inking)	Average values Rejects from a RCF newsprint mill (with de-inking)
Dust	mg/Nm ³	3.2	6.6
SO ₂	mg/Nm ³	26.0	1.2
NO _x	mg/Nm ³	195	“95:271;“96:227;
CO	mg/Nm ³	14.1	“97:176
HCl	mg/Nm ³	1.7	14
HF	mg/Nm ³	0.06	2.6
Total-C	mg/Nm ³	1.4	no data (n.d.)
Cd, TI	µg/Nm ³	< 17.0	1.1
Hg	µg/Nm ³	5	(n.d.)
Sb, As, Cr, Co, Cu,	µg/Nm ³	71.0	(n.d.)
Mn, Ni, V, SN			(n.d.)
Dioxins/Furans	ngI-TE/Nm ³	0.097	(n.d.)

2.4.2 Effluents

Effluents to wastewater will depend on the production processes and operational standards. Pulp and paper processes discharge organic matter and nutrients originating from raw materials and also from chemicals used in different stages. The highest load of organic matter comes from the residual cooking liquor produced in chemical sulfate pulping. This is usually regenerated for re-use and for use as fuel. The recovery of spent pulping liquors in mills using non-wood raw materials is less common due to the lack of feasible recovery systems and silica removal technology. This spent liquor is therefore often discharged without treatment leading to a very significant environmental impact.

Raw fiber Material Handling: The effluent from wet depithing must be treated to remove suspended solids and to reduce BOD. Discharges vary depending primarily on how much of the depithing is done at the mill but also on the depithing process and the condition of the bagasse. The following effluent characteristics for wet bagasse handling including depithing indicate the magnitude and the variability:

BOD5 20-60 kg/t bagasse
 COD 30-180 kg/t bagasse
 SS 300-400 kg/t bagasse

Sulfate (kraft) pulping : Spent cooking liquor from the digester contains the largest amounts of dissolved organic material of all process liquors. The detailed composition and the environmental impact of the liquor (if not recovered) depend on

the fiber raw material, the pulping yield and the process conditions. Part of the dissolved material is volatile, it will be released from the liquor and appear as condensates when lowering the digester pressure. Typical BOD and COD values for the spent liquor (considered as discharge if no recovery exists) from kraft pulping are as follows:

Process	Fibre raw material	Pulp yield %	BOD7 Kg/t	COD Kg/t
Soda	Straw	50	250	930
Soda	Cotton	55	340	970
Soda	Bagasse	80	256	750
Sulphate	Bagasse	48	350	1340

Bleaching Chemical Pulps: In a typical pulp and paper mill in Egypt, the bleaching process is performed for chemical pulp that is produced locally (bagasse/rice straw) and/or imported pulp that may be produced from wood or non-wood fiber materials. Bleaching effluents contain dissolved chlorinated material if chlorine, hypochlorite or chlorine dioxide has been used as the bleaching agent (conventional bleaching). Bleaching effluents also contribute to the BOD, COD, toxicity and color of the total mill effluent. The environmental load increases with the increase of lignin content of the unbleached pulp, amounts of dissolved material entering from the cooking, charged chemicals and bleaching temperature. In conventional bleaching the effluent characteristics are not markedly changed by different processes or raw materials as seen in the following table, but the intense alkaline conditions in viscose pulp bleaching produce high BOD/COD effluents.

Pulping process	Fibre raw material	BOD (kg/t)	COD (kg/t)
Soda	Straw	16	60
Sulphate	Bamboo	17	90
Sulphate	Eucalyptus	14	60
Sulphate	Pine	15	80
Sulphite (paper)	Softwood	15	60
Sulphite (viscose)	Softwood	30-40	-

Effluents from conventional bleaching contain a complex mixture of chlorinated organic compounds corresponding to 4-10 kg AOX/t pulp (adsorbable chlorinated organics). Most of that material is in a form with high molecular mass and a low degree of chlorination. A small fraction of the chlorinated material is low molecular, slowly degradable and may bio-accumulate and show biological activity. If the raw material contains relatively high amounts of easily dissolved matter, e.g. remaining sugar in bagasse, the pollution load will increase.

Recycled Fiber Pulping: Wastepaper collected from landfills, as often the case, may have some polluting effect. Pollution from landfill comes primarily from methane or

other hydrocarbons generated as the cellulose decomposes anaerobically. Wastepaper pulping processes give rise to a certain amount of pollution in the form of materials contained in the process water discharged from the plant, in the material collected during processing and in the gases discharged to the atmosphere by burning waste material. Some typical figures relevant to polluting materials generated during RCF pulping (kg/ton of pulp) are as follows:

Type of waste paper	BOD kg/t	COD kg/t	Comment
Mixed waste paper	5-15	10-40	Depends on contaminants
Commercial waste paper	5-10	10-30	Little contamination, depends on starch content
Old newspapers	20-40	40-90	De-inking increases loads
Old corrugated containers	5-15	10-40	Depends on starch and glue
Selected wood free waste papers	5-50	10-100	Wide range depends on starch

Papermaking Process: In the table below, typical numbers are given for the net flow of excess water from the papermaking process in m³/ADt of paper, not including the water from other sources. The measurements for suspended solid, BOD and COD in kg/ADt are taken before any effluent treatment plant so that they represent what is actually discharged from the paper mill. The emissions also include the discharges that are not directly related to the uninterrupted paper production such as overflows, spillage leaks, washouts of chests and wet ends, cleaning and washing size presses and coater heads. In the table, two classifications of paper machine are considered, low environmental status and medium/high environmental status.

Discharge parameter	Low environmental status	Medium/high environmental status
Excess flow (m ³ /t)	50-200	5-50
Suspended solids SS (kg/t)	30-70	10-30
BOD ₇ (kg/t)	4-10	2-10
COD (kg/t)	8-25	4-20
P (g/t)	3-300	3-300
N (g/t)	10-500	10-500

2.4.3 Solid wastes

Waste is formed at all stages in the pulp and paper life cycle. Solid wastes generated from a waste paper pulping operation vary considerably depending upon the degree of cleaning set up within the process. The yield of the pulp is inversely proportional to the amount of material removed. Sludge constituents from waste paper pulping vary with the type of waste paper used. They most often include clay and other fine inorganic fillers, fine plastic debris and organic materials from inks. Also fibre from the paper is always present. When dry, these materials landfill quite satisfactorily. Waste paper sludge is often difficult to de-water. A significant amount of water is sufficient to accommodate bacteria, which rapidly produce hydrogen sulphide and other noxious or dangerous gases. Landfilling of wet sludge can produce considerable odour problems.

2.4.4 Hazardous wastes

The amount of hazardous waste generated in the pulp and paper industry is limited. Examples of substances that may be generated or that may result from the operations in the industry and that have to be classified as hazardous waste are:

- ☐ Heavy metals such as cadmium, chromium and mercury
- ☐ Polychlorinated biphenyls (PCBs) being used as coolant – insulation fluids in transformers and capacitors and sometimes as additives to some epoxy paints
- ☐ Cyanides
- ☐ Herbicides
- ☐ Solvents, in particular chlorinated ones like dichloromethane (DCM), trichloromethane or chloroform, and tetrachloromethane also referred as carbon tetrachloride
- ☐ Chlorofluorocarbons (CFCs) commonly called “freons”, which are used as process media in refrigerators and heat pumps
- ☐ “Halon” that are bromine (together with chlorine and / or fluorine) containing substances that are being used in fire extinguisher systems
- ☐ Paints and varnishes
- ☐ Glue
- ☐ Acids and alkalis
- ☐ Oil and grease

Radioactive sources (from instruments like level controls)

In addition, printing inks contain a variety of materials some of which, mainly heavy metals, are listed as hazardous. Some dioxins have been also reported. Burning waste paper sludge is considered as an environmentally acceptable option for heat generation to replace of fossil fuels. However, there is a potential of airborne dispersion of heavy metals and other pollutants.

2.5 Characteristics of the pulp and paper industry

The following characteristics of the Pulp and Paper industry should be considered in the planning and conducting the self-monitoring activities.

- Mills can be either integrated or non-integrated. The configuration of each mill depends on the combination of the employed processes, equipment and installations.
- Integrated and non-integrated mills have different features of the water management system in terms of re-circulation of process water, discharges, and pollution loads.
- Integrated and non-integrated mills that include chemical pulping process have to have effective wastewater treatment plants. This is due to the expected high pollution loads.
- Kraft pulping mills using rice straw as a fiber raw material need a special focus on the practices for dealing with black liquor. Wastewater may be contaminated with the spent liquor.
- Kraft pulping mills using bagasse as a fiber raw material need a special focus on the air emissions from the recovery boilers.

3. ENVIRONMENTAL AND HEALTH IMPACTS OF POLLUTANTS

The main environmental impacts arising from pulp and paper making stem from the use of resources at the mills themselves. Significant impacts also arise from other associated activities e.g. chemicals manufacture and the use, which generate residuals that often enter the environment. Residuals of process chemicals and fiber raw materials are also released to air or water and appear as solid waste streams. In addition, fibers and fiber fragments appear in the aqueous waste streams and have an impact both on the visibility of the receiving waters and on the bottom structure. By altering the color of receiving waters, dissolved components can reduce light penetration and endanger the aquatic life. Other dissolved components exert toxic properties on the aquatic fauna. An important air quality problem is the release of smelling reduced sulfur and noxious compounds from the sulfate (kraft) pulping process.

3.1. Impacts of air emissions

- | | |
|--------------------------------------|---|
| <i>a) Particulate matters</i> | Recent epidemiological evidence suggests that much of the health damage caused by exposure to particulates is associated with particulate matters smaller than 10 μ m (PM ₁₀). These particles penetrate most deeply into the lungs, causing a large spectrum of illnesses (e.g. asthma attack, cough, bronchitis). Emissions of particulates include ash, soot and carbon compounds, which are often the result of incomplete combustion. Acid condensate sulfates and nitrates as well as lead, cadmium, and other metals can also be detected. |
| <i>b) Sulfur Oxides</i> | Air pollution by sulfur oxides is a major environmental problem. This compound is harmful to plant and animal life, as well as many building materials. Another problem of great concern is acid rain, which is caused by the dissolution of sulfur oxides in atmospheric water droplets to form acidic solutions that can be very damaging when distributed in the form of rain. Acid rain is corrosive to metals, limestone, and other materials. |
| <i>c) Nitrogen Oxides</i> | Nitrogen oxides also dissolve in atmospheric water droplets to form acid rain. |
| <i>d) Carbon dioxide</i> | Combustion of fossil fuels to produce electricity and heat contribute to the green house effect caused by the formation of carbon dioxide. The greenhouse phenomenon occurs when heat radiation from earth is absorbed by the gases causing a surface temperature increase. |

- f) *Water Vapor (Humidity)* Humidity in workplace is regulated by law 4/1994 due to its effect on the respiratory system especially for people suffering from asthma.

- g) *VOCs* VOCs emitted from the processing, storage and handling of raw material and from all combustion processes, consist of various substances, which can contribute to the formation of tropospheric or low level ozone, which has a direct environmental impact on vegetation and crops.

- h) *Odor* Odor is caused by inorganic and organic sulfides formed in the process. They have a characteristic, unpleasant smell but do not constitute a health hazard at the typical levels at which they occur. Odor is not a health issue but the disturbance and aesthetic implications are such that this problem should be considered.

3.2. Impact of effluents

Discharges of organic matter will result in oxygen consumption by degradation reactions in the receiving waters. The organic material in wastewater stimulates the growth of bacteria and fungi naturally present in water, which then consume dissolved oxygen. The environmental impacts of this depend on the characteristics of such water bodies. Discharge of polluted wastewater high in BOD into lakes and sea can cause eutrophication and impact bio-diversity. Sudden discharge of high BOD loads to the public sewer system will have an indirect environmental impact. Shock loads can cause malfunction of the domestic wastewater treatment plant. Bleaching with high charges of chlorine compounds causes a specific environmental problem by generating persistent (long-lived) toxic polychlorinated compounds that can bio-accumulate in living organisms.

The color of effluent is associated with the high molecular weight organic compounds; i.e. lignin derivatives from the cooking and bleaching. The main effect of color is the reduction of the light transmission in the water phase, which decreases the productivity of the receiving water. The impact of color changes in each particular case depends very closely on the overall productivity and original color of the receiving waters. Inorganic compounds in the effluents from pulp production seldom give rise to environmental effects. One exception is chlorate, formed during bleaching with chlorine dioxide. It is highly toxic to algae and cause indirect effects on other organisms living in the algal communities. Chlorate can be removed effectively by external biological treatment. Discharges of nitrogen and phosphorus may increase nutrient levels in receiving waters, leading to increased biomass production, higher oxygen consumption and, eventually, eutrophication. Several levels in the ecosystem are usually affected when the nutrient balance is disturbed. Spent lube oil from garage and workshops could be a cause for concern if discharged into the sewer system.

3.3. Impact of solid wastes

Organic waste from production processes, such as sludge from external treatment, may cause environmental impacts at disposal. Ashes, slag and other inorganic process waste usually go to landfill. To minimise environmental impacts and optimise disposal it is important to fractionate waste generated and find new use for residual materials that can be re-used. On the other hand, the amount of hazardous waste generated in the pulp and paper industry is limited.

3.4 Available emissions data on local industry

3.4.1 Mill I

The following is the available data on the emissions from two mills in Egypt, as provided to EPAP.

Air Emissions and Noise Measurements in pulp Production Departments

Process	Dust mg/m ³	Chlorine ppm	Noise decibels
Straw cutting	1.27 – 4.83	-	81.7
Pulp washing	0.92	-	85.2
Pulp bleaching	0.98 – 1.06	0.02 – 0.09	71.1
Straw storage	2.80	-	71.0
Max. allowable	10	1	90

Air Emissions and Noise Measurement in Papermaking Department

Process	Sulphuric acid vapor mg/m ³	Temperature °C	Noise, decibels
Stock preparation	0.54	-	85.7
PM dryers	0.14	25.8	83.1
Re-winder & Cutter	-	-	87.2
Max. allowable	1	29.5	90

Air Emissions in Bleaching Chemical Production

Chlorine production	Cl ppm	Dust mg/m ³
Cells	0.33	-
Outside control rooms	0.014	-
Inside control rooms	0.011	-
Hypo production	-	-
Pumping section	0.01 – 0.29	0.25 – 0.89
Lime store	-	1.16
Max. allowable	1	2

Air Emissions from Boiler Chimneys

Boiler	CO mg/m ³	SO mg/m ³	Nitrogen dioxide mg/m ³	Dust, mg/m ³
No 2	415.8	189.8	Not detectable	16.9
No 3	473.2	382.2	-	22.6
No 4	392.4	223.6	-	12.8
No 5	389.8	509.6	-	33
Max. allowable	5000	4000	3000	200

The dust emissions of the mill were also measured outside the plant from four different locations.

Dust Ambient Air Measurement outside the Mill

Locations	Dust $\mu\text{g}/\text{m}^3$
Location 1	136.2
Location 2	88.3
Location 3	104.9
Location 4	83.3
Max. allowable	230

Wastewater pollution loads

Description	M3/D	BOD Kg/d	COD Kg/d
Straw preparation	15600	4513	37487
Digesters/washing (black liquor)	20440	71042	263174
Screening	1322	22	326
Bleaching	12400	1689	29094
PMs 1, 2 and 3	13000	914	5578
Board mill	3000	1260	9006
Chlor – alkali plant	1000	272	4757
Water / boiler plant	1000	155	4065
Total	67762	79868	350487

3.4.2 Mill II

Emissions from boilers are the only available data on air emissions:

Parameter	Boiler 1	Boiler 2
Combustion efficiency/%	87.8	82.0
Carbon monoxide/ppm	81	82
Carbon dioxide/%	11.4	2.8
Oxides of Nitrogen/ppm	120	21
Sulfur dioxide/ppm	206	60

Wastewater pollution loads:

Description	Load Kg/day
Straw pulping/COD	5000
Paper mill/COD	30000
Paper mill/BOD	11000
Paper mill/SS	24000

The following table presents the wastewater pollution load from 6 various paper machines:

Paper Machine	Drain Liter/min.	Load Ton/ Day		
		S. S	COD	BOD
1	2428	3.46	3.12	1.25
2	2383	4.84	3.25	1.3
3	1887	3.04	1.41	0.56
4	3210	2.98	2.05	0.83
5	1935	2.96	1.95	0.78
6	2060	1.1	4.18	1.67

4. EGYPTIAN LAWS AND REGULATIONS

There are a number of laws and regulations that address the different environmental violations. The following are the laws applicable to the pulp and paper industry.

4.1 Concerning air emissions

Article 40 of Law 4/1994, article 42 of the executive regulations and annex 6 deal with gaseous emissions from combustion of fuel. The statutes relevant to the fuel combustion are:

- ☐ The use of solar oil and other heavy oil products, as well crude oil shall be prohibited in dwelling zones.
- ☐ The sulfur percentage in fuel used in urban zones and near the dwelling zones shall not exceed 1.5%.
- ☐ The design of the burner and fire-house shall allow for complete mixing of fuel with the required amount of air, and for the uniform temperature distribution that ensure complete combustion and minimize gas emissions caused by incomplete combustion.
- ☐ Gases containing sulfur dioxide shall be emitted through chimneys, which are rising sufficiently high, in order that these gases become lighter before reaching the ground surface. Otherwise, using fuel that contains high proportions of sulfur in power generating stations, as well as in industry and other regions lying away from inhabited urban areas. This will provide that atmospheric factors and adequate distances to prevent these gases from reaching the dwelling and agricultural zones and regions, as well as the water courses shall be observed.
- ☐ Chimneys from which a total emission of wastes reaches 7000 – 15000 kg/hr, shall have heights ranging between 18 – 36 meters.
- ☐ Chimneys from which a total emission of gaseous wastes reaches more than 15000 kg/hour, shall have heights exceeding at least two and a half times the height of surrounding buildings, including the building served by the chimney.
- ☐ The permissible limits of emissions from sources of fuel combustion are given in table 2.

Table 2. Maximum limits of emissions from sources of fuel combustion

Pollution	Maximum limit, mg/m ³ of exhaust	
	Existing	New
Sulfur Dioxide.	4000	2500
Carbon Monoxide.	4000	2500
Volatized ashes in urban regions.	250	250
Volatized ashes in remote regions.	500	500
Smoke.	250	250

4.2 Concerning effluents

Limits for pollutants in wastewater vary depending on the type of receiving water body. The parameters that should be monitored and/or inspected are BOD, COD, pH, temperature, residual chlorine, TSS, TDS, Oil and Grease. Table 3 presents the permissible limits for discharges to the different recipients (sea, Nile, canals, agricultural drains, public sewer) according to the different relevant laws. Spent lube oil has a negative impact on water and soil and therefore its disposal should be monitored/inspected. A record should be kept for this purpose.

4.3 CONCERNING SOLID WASTE

A number of laws address solid waste management. The following laws apply to scrap and sludge from the WWTP:

- ☐ Law 38/1967, which addresses public cleanliness, regulates the collection and disposal of solid wastes from houses, public places, commercial and industrial establishments.
- ☐ Ministry of Housing, Utilities and Urban Communities (MHUUC) decree No. 134 of 1968, which provides guidelines from domestic and industrial sources, including specifications for collection, transportation, composting, incineration and land disposal.
- ☐ Law 31/1976, which amended law 38/1967
- ☐ Law 43/1979, the Law of Local administration, which provided that city councils are responsible for “physical and social infrastructure”, effectively delegating responsibility for infrastructure functions.
- ☐ Law 4/1994 regulates incineration of solid waste

4.4 Concerning work environment

Violations of work environment could be encountered:

- In the boiler house: gas emissions, regulated by article 43 of Law 4/1994, article 45 of the executive regulations and annex 8. The limits for the relevant pollutants are presented in Table 4.
- Wherever heating is performed: temperature and humidity are regulated by article 44 of Law 4/1994, article 46 of the executive regulations and annex 9.
- Near heavy machinery: noise is regulated by article 42 of Law 4/1994, article 44 of the executive regulations and table 1, annex 7.
- Ventilation is regulated by article 45 of Law 4/1994 and article 47 of the executive regulations.
- Smoking is regulated by article 46 of Law 4/1994 and article 48 of the executive regulations, and Law 52/1981.
- Work environment conditions are addressed in Law 137/1981 for Labor, Minister of Housing Decree 380/1983, Minister of Industry Decree 380/1982

Table 3 Egyptian Environmental Legal Requirements for Industrial Wastewater

Parameter (mg/l unless otherwise noted)	Law 4/94: Discharge Coastal Environment	Law 93/62 Discharge to Sewer System (as modified by Decree 44/2000)	Law 48/82: Discharge into :			
			Underground Reservoir & Nile Branches/Canals	Nile (Main Stream)	Drains	
BOD (5day,20 deg.)	60	<600	20	30	Municipal	Industrial
COD	100	<1100	30	40	60	60
pH (Grease)	6-9	6-9.5	6-9	6-9	80	100
Oil & Grease	15	<100	5	5	6-9	6-9
Temperature (deg.)	10C>avg. temp of receiving body	<43	35	35	10	10
Total Suspended Solids	60	<800	30	30	35	35
Settable Solids	—	<10	—	20	50	50
Total Dissolved Solids	2000	—	800	1200	—	—
Chlorine	—	<10	1	1	—	—
PO ₄	5	30	1	1	—	10
Total phosphorus		25				
Fluoride	1	<1	0.5	0.5	—	0.5

Parameter (mg/l unless otherwise noted)	Law 4/94: Discharge Coastal Environment	Law 93/62 Discharge to Sewer System (as modified by Decree 44/2000)	Law 48/82: Discharge into :			
			Underground Reservoir & Nile Branches/Canals	Nile (Main Stream)	Drains	
Cadmium	0.05	0.2	0.01	0.01	—	—
Chromium	1		—	—	Total concentration for theses metals should be: 1 for all flow streams	
Chromium Hexavalent	—	0.5	0.05	0.05		
Copper	1.5	1.5		1		
Iron	1.5		1	1		
Lead	0.5	1	0.05	0.05		
Mercury	0.005	0.2	0.001	0.001	—	—
Nickel	0.1	1	0.1	0.1	—	—
Silver	0.1	0.5	0.05	0.05	—	—
Zinc	5	<10	1	1	—	—
Cyanide	0.1	<0.1	—	—	—	0.1
Total heavy metals	—	Total metals should not exceed 5 mg/l	1	1	1	1

Table 4 Permissible limits as time average and for short periods

Material	Threshold			
	Time average		Exposure limits for short periods	
	ppm	mg/m³	ppm	mg/m³
Ammonia	25	18	35	27
Carbon dioxide	5000	9000	15000	27000
Carbon monoxide	50	55	400	440
Sulfur dioxide	2	5	5	10

4.5 Concerning hazardous materials and wastes

The hazardous chemicals used in the lab and the fuel for the boilers, fall under the provisions of Law 4/1994. Articles 29 and 33 of the law makes it mandatory for those who produce or handle dangerous materials in gaseous, liquid or solid form, to take precautions to ensure that no environmental damage shall occur. Articles 25, 31 and 32 of the executive regulations (decree 338/1995) specify the necessary precautions for handling hazardous materials. Storing of fuel for the boilers is covered by the Law 4 as hazardous material There is no explicit articles in Law 4/1994 or in decree 338/1995 (executive regulations), regarding holding a register for the hazardous materials; article 33 is concerned with hazardous wastes. However, keeping the register for the hazardous materials is implicit in article 25 of the executive regulations regarding the application for a license.

4.6 Concerning the environmental register

Article 22 of Law 4/1994 states that the owner of the establishment shall keep a register showing the impact of the establishment activity on the environment. Article 17 and Annex 3 of the executive regulations specify the type of data recorded in the register.

The emergency response plan and the hazardous materials register will also be part of the environmental register as stated in part 4.5.

5. METHODS AND TECHNIQUES FOR POLLUTION ABATEMENT

The pulp and paper industry has historically been considered a major consumer of natural resources, including water and energy, and a significant contributor of pollutant discharges to the environment. Measures for reducing the environmental impact of pulp and paper mills have been developed. For example, there is a development to close up water circuits in pulp and paper mills and a further reduction of discharges can be expected. Also, the sulfur air emissions have been reduced considerably by large progresses of process technology. A marked reduction of both chlorinated and non-chlorinated organic substances in the effluents of pulp mills has been achieved by in-process measures. The installation of external treatment plants has mostly decreased the organic load (COD, BOD). In addition to process changes, treatment plants decreased emissions of AOX and unchlorinated toxic organic compounds into receiving waters. The emissions and the common abatement measures for the main processes in the pulp and paper industry are herein summarized.

5.1 Emissions to air

The main sources for air emissions to the atmosphere from pulp and paper mills include chip storage, cooking digester, pulp washing, bleaching plant, chemicals recovery, evaporation, bark furnace, recovery boiler, white liquor preparation, lime kiln, tanks and pulp drying (only for market pulp). Air emissions consist mainly of sulfur-containing compounds such as sulfur dioxide and malodorous reduced sulfur compounds. From furnaces nitrogen oxides are also emitted and furthermore small amounts of dust (solid particulates) as fly ash. From bleach plants and from bleaching chemical preparation, chlorine compounds may leak to the atmosphere. The fuels used in the boilers may include fuel oil, natural gas, fibrous sludge, and other fiber raw material residues from effluent treatment. The emissions from power production are dependent on the fuel, the fuel mixture and the impurities content.

Control Techniques

In kraft mills, concentrated gases come from digester, evaporation plant and condensate stripper. Concentrated gases are collected and burnt either in the limekiln, the recovery boiler or in a separate burner. If a dedicated burner is used, a scrubber is normally added to control emission of the SO₂ formed. Diluted gases come from screening, pulp washing, smelt dissolver and ventilation of various tanks that contain black liquor etc. Diluted gases at some mills are collected and burnt in the recovery boiler, in the limekiln, or scrubbed.

The recovery boiler is equipped with an electrostatic precipitator in order to remove the large amount of particulates (mainly Na₂ SO₄) from the flue gases. The dust is fed back into the furnace by mixing into the strong black liquor. In order to decrease the SO₂ emissions from the recovery boiler, it is often equipped with a flue gas scrubber operating at pH 6-7. Reduced NO_x can normally be achieved by modifications to the air feed system and optimizing combustion conditions. In pulp production mills, fossil fuel is the main fuel in auxiliary boilers. If the fuel contains sulfur, sulfur emissions can be prevented by the addition of lime to the bed.

In sulfite mills, sulfur emission levels and the potential of further reductions are highly mill dependent. Cyclones, scrubbers, and recovery boilers can be found in sulfite pulp mills for collecting and purifying emissions to the atmosphere.

5.2 Wastewater discharges

In kraft pulping, emissions to water are dominated by oxygen consuming organic substances, which are measured as COD and BOD. Effluent from bleach plant, where chlorine-containing bleaching chemicals are used, contains organically bound chlorine compounds, measured as AOX. In addition, the effluents may also include lower concentrations of metals extracted from the wood. The main sources of wastewater are:

- ☐ Wastewater from raw material handling
- ☐ Condensates from cooking and evaporation
- ☐ Spills from different process departments
- ☐ Black liquor residues (washing losses) from the handling of unbleached pulp
- ☐ Discharges from the bleach plant

Wastewater from a RCF paper mill is mainly generated during cleaning steps. It is common practice to withdraw wastewater at locations where the process water is mostly polluted. The process water is mainly contaminated during cleaning, deinking and fiber recovery. Therefore, wastewater from RCF based paper mills consists of water from reject separation by screens and centrifugal cleaners; filtrates from washers, thickeners and sludge handling; and excess white water depending on the rate of recycling.

Control Techniques

In general, any water passing through an industrial process is degraded by the addition of pollutants. Therefore, closing the water circuit and reducing the fresh water input reduces the water reaching the water treatment plant. The principles for reducing the use of fresh water include reducing the gross requirements, avoiding inhibiting interactions to the closure of the water circuits, and recycling water specially unclarified whitewater, clarified whitewater generated usually in the save-all, and fresh water generated by purification of clarified water.

Discharges from a pulp and paper mill before treatment are mainly dependent on the employed processes and chemicals used. Typically, the treatment of wastewater includes primary treatment, sedimentation and secondary biological treatment. Aerated lagoon can be modified to incorporate sludge recycling. In that case, the treatment efficiency approaches that of an activated sludge plant.

Primary treatment: The objective of this stage is the removal of particulate solids. Settlement and dissolved air flotation systems are used at most types of mills. Settlement systems can produce well-clarified waters, but can suffer from operating difficulties (floating solids and odor), particularly when treating stronger, warmer wastewater. High-rate settlement units are used for treating specific streams such as coating wastewater. Chemical pre-treatment (e.g. polyelectrolytes, inorganic coagulants and bentonite) is often practiced to enhance the removal of colloidal solids and/or to increase settlement velocities.

Secondary treatment: The objective of this stage is the removal or reduction of BOD and COD, which can be achieved by genuine degradation or by adherence of the pollutants to the sludge. The latter mechanism will also remove non-biodegradable materials such as heavy metals. Dioxins, furans and DDT would be expected to bind to the biomass and fiber sludge almost totally. Hexachlorobutadiene, aldrin, dieldrin, hexachlorobenzene, endrin, PCBs, trichlorobenzene and heavy metals will also be partially removed by this mechanism. The basic alternatives are aerobic and anaerobic biological systems. There are many designs of each. In an aerobic plant, air, oxygen or a combination can be utilized. The use of oxygen improves performance and control and can be retrofitted to existing plants.

Tertiary treatment: Tertiary treatment, as a control technique, can more be associated with emerging techniques than normal control regarding pulp and paper wastewater. Irrespective of the type of treatment provided, all operators should assess the possibility of recycling the treated wastewater in a partially or fully closed system taking the following factors into account:

- ☐ In large mills, treated wastewater is being recycled to the mill in a tertiary loop for use in specific areas or after blending with fresh water. This technique allows the use of fresh water to be reduced
- ☐ Membrane or possibly evaporative plant could avoid the need for conventional abatement plant, and by generating all the fresh water needs from the recycled water, an effluent-free system can be created with fresh water make-up required only to balance evaporative losses.

In order to optimize the treatment of wastewater plant, the following general principles should be applied in sequence to control emissions to water:

- ☐ Water use should be minimized and wastewater reused or recycled. Uncontaminated roof and surface water, which cannot be used, should be discharged separately.
- ☐ Techniques to minimize contamination risk of process or surface water should be implemented.
- ☐ Generally, effluent streams should be kept separate, as treatment will be more efficient.
- ☐ Systems should be engineered to avoid effluent by-passing the treatment plant.
- ☐ With regard to BOD, the nature of the receiving water should be taken into account.

5.3 Solid wastes

In pulp and paper industry, chemical processes generate various amounts of solid waste: inorganic sludge from the chemical recovery; residues from raw material handling; sludge from effluent treatment; dust from boilers and furnaces; ashes and miscellaneous material. In general, the waste streams may comprise:

- ☐ Sludge comprising mainly fibers, fillers and inks from any de-inking plant
- ☐ Raw material wastes e.g. rice straw.
- ☐ Reject pulp fibers from cleaning stages and miscellaneous trash
- ☐ Boiler plant ash.
- ☐ Containers of Chemicals and general industrial waste.

Control of Solid waste

Many organic substances, which might be considered waste products, are burnt for energy recovery. The sludge is usually thickened before being de-watered in a filter press, screw press or on a vacuum filter. Disposal of sludge depends on the amount, moisture content and other characteristics. The general techniques for improved solid waste management systems include the following:

- ☐ A system should be maintained to record the quantity, nature, origin and where relevant, the destination, frequency of collection, mode of transport and treatment method of any waste which is disposed of or recovered.
- ☐ Wherever practicable, waste should be segregated and the disposal route identified which should be as close to the point of production as possible.
- ☐ Records should be maintained of any waste sent off-site.

5.4 Pollution prevention & cleaner product6ion

The concept of pollution prevention is widely accepted in the industry due to its economic and environmental benefits. However, most conventional, end-of-pipe treatment technologies are not effective in destroying many chlorinated compounds and often merely transfer the pollutants to another environmental medium. Efforts to prevent chlorinated releases have, therefore, focused on source reduction and material substitution techniques such as defoamers, bleaching chemical or wood chip substitution to reduce the industry's use and releases of chlorinated compounds. Such source reduction efforts and material substitutions usually require substantial changes in the production process. In addition, the industry is implementing a number of pollution prevention techniques to reduce water use and pollutant releases such as: improved spill control, bleach filtrate recycle, closed screen rooms, and improved storm water management.

The chemical recovery systems used in chemical pulping processes are an example of pollution prevention technologies that have evolved alongside process technologies. Many recent pollution prevention efforts in the pulp and paper industry have focused on reducing the releases of toxics, in particular, chlorinated compounds. Pollution prevention techniques have proven to be more effective in controlling these pollutants than conventional control and treatment technologies. Because the pulp and paper industry is highly capital intensive and uses long-

established technologies with long equipment lifetimes, major process-changing pollution prevention opportunities are expensive and require long time periods to implement.

On the other hand, the pulp and paper industry is a dynamic one that constantly makes material substitutions and process changes to increase productivity and cut costs. The relevant pollution prevention and cleaner production techniques for the main processes in the pulp and paper industry are herein summarized. Regarding the local conditions, the focus will be on applicable techniques for non-wood raw fiber material handling. Also, the most common practices being used in kraft, recovered paper and paper manufacturing processes are described. In addition, a number of recommendations for pollution prevention that are relevant to the Egyptian industry are presented.

5.4.1 Handling of Non-Wood Fiber Raw Materials

Non-wood fibre comes predominantly from agricultural residues and is thus a by-product of crops planted, harvested and used for other purposes than papermaking. The main environmental impacts from using these residues as a raw material relate to the use of land, water, fertilisers and pesticides during cultivation and so, precautions that can be taken to minimise impacts during harvesting and handling should carefully be considered.

Generally, an integrated sugar-pulp-paper mill could be highly advantageous. Such a plant would minimise transportation, maximise the use of the energy generated from the residuals or spent pulping liquors and use common resources for maintenance, management etc.

Straws

- ☐ The objective is to minimise environmental impacts mainly related to minimising the silica content of the raw material:
- ☐ Keep the material clean and avoid contamination from soil and stones in the field
- ☐ Cover and pack the material in bales to protect from dust and for ease transportation.
- ☐ Straw should be stored in 8-15% moisture to avoid self-combustion.
- ☐ Wet de-dusting is recommended before cutting to remove sand and other impurities. The effluent from de-dusting should pass into the sedimentation basin of the mill.

Bagasse

When handling bagasse, focus should be placed on removal of the pith, the thin walled non-fibrous parenchyma cells that contain the sugar juice. Pith contamination leads to higher chemical consumption during pulping and to disturbances during washing and papermaking. These process problems also have negative environmental impact i.e. higher discharges and/or energy use. Also, the pith

constitutes a valuable fuel that should be used, primarily in the sugar mill. Guidelines for the clean processing of bagasse deal mostly with pith handling.

- ☐ Dry the pith before burning to increase the thermal efficiency of the boiler.
- ☐ Efficient removal of tops and leaves also helps to minimise the input of silica.
- ☐ Baling is recommended to facilitate handling and for storage bales should be stacked in layers with suitable intervals to aid drying.
- ☐ In wet piling, leachate from the pile must pass primary and secondary treatment before discharge.

5.4.2 Handling of Spent Liquors

The properties of non-wood black liquors differ in many respects from those of wood-based black liquors and place special demands on the design of evaporation and combustion equipment. If compared to wood-based liquors, non-wood liquors are characterised by:

- ☐ High viscosity at given solids content and temperature
- ☐ High silica content
- ☐ Low heat value per kg of dry solids for straw liquors
- ☐ Low “swelling index” resulting in harder-to-burn liquor particles in the recovery furnace
- ☐ High content of organic fines

For evaporation of non-wood liquors, short tube vertical evaporators (STV) are considered to be more efficient than long tube vertical evaporators (LTV), which used to be standard for wood black liquors. Control of pH at around 11 helps avoid hydrolysis of dissolved silicate into silicic acid (silica) as well as lignin precipitation, keeping heat transfer surfaces clean. The total evaporation load is usually high, as the initial concentration of non-wood weak black liquor is low, typically 8-10 % dry solids. Thus, a primary requirement would be to accomplish a higher initial concentration by efficient brown stock washing.

A common problem in all non-wood pulping processes is the relatively high levels of silica resulting from the raw materials e.g. straw, bagasse, etc. Typical concentrations of silica in black liquor solids are presented below; which shows that its percentage is much higher when rice straw is used:

Raw material	Silica % (Range)
Rice Straw	3-16
Bagasse	1-3

High silica levels cause fouling/deposits on heat transfer surfaces and difficulties in pumping and concentration of black liquor due to increased viscosity. High concentration of silica also increases the smelt melting temperature. Silica in green liquor is to large extent transferred to the lime during causticsication and will accumulate in the lime cycle. At moderate silica levels a two-stage causticising process has been suggested, assuming that a large proportion of silica precipitates in

the initial causticising stage from which then lime mud is removed, while the second stage lime mud is re-burned.

Controlled precipitation and silica removal can be achieved by lowering the pH of the black liquor e.g. by carbonation with the flue-gas. The silica enriched sludge product removed may be used for other industrial processes (cement, porcelain). After the de-silication of black liquor it is necessary to restore the residual alkali by increasing the pH of the liquor again.

Besides chemicals and energy recovery there are alternative uses for black liquor, not least in the case of small, non-wood pulp mills:

- ☐ Unconventional energy production
- ☐ Utilisation of separated black liquor lignin
- ☐ Utilisation of lignin compounds
- ☐ Utilisation of other black liquor compounds

In cases where no recovery process is technically or economically feasible, external methods of effluent treatment or disposal must be applied.

5.4.3 Kraft Pulping

The following are the recommended techniques for pollution prevention and cleaner production in the kraft chemical pulping processes. These recommendations can be grouped in three categories: general recommendations, process specific opportunities and pollution control practices.

General Recommendations:

- ☐ Collection of almost all spillage
- ☐ Stripping and re-use of condensates
- ☐ Buffer tanks for concentrated liquids

Process Specific Opportunities

Washing and Screening:

- ☐ Closed screening
- ☐ Efficient washing and process control

De-lignification:

- ☐ Oxygen de-lignification

Bleaching:

- ☐ Ozone bleaching
- ☐ ECF bleaching technique
- ☐ TCF bleaching technique
- ☐ Partly closure of the bleach plant + increased evaporation

Recovery System:

- ☐ Installation of scrubbers on the recovery boiler
- ☐ Incineration of odorous gases in the recovery boiler
- ☐ Incineration of odorous gases in the lime kiln

Pollution Control Practices

- ☐ Biological treatment
- ☐ Tertiary treatment (precipitation)

5.4.4 Recovered Fiber

The following are the recommended techniques for pollution prevention and cleaner production in recovered paper processing. These recommendations can be grouped in two categories: general recommendations and pollution control practices. Other process specific options will be explained in section “5.6 P2 opportunities in Egypt”, which mainly focuses on improving the current processes to meet the recommended industry practices.

General Recommendations:

- ☐ Separation of less contaminated water from contaminated one and recycling
- ☐ Optimal water management (water loop arrangement) and water clarification
- ☐ Reduction of fresh water consumption by strict separation of water
- ☐ Co-generation of heat and power
- ☐ Reject and sludge handling and processing on-site
- ☐ Environmentally sound residue utilization and disposal

Pollution Control Practices

- ☐ Closed water loop with in-line biological process water treatment
- ☐ Aerobic biological wastewater treatment
- ☐ Anaerobic techniques as first stage of biological wastewater treatment
- ☐ Generation of clarified water for de-inking plants

5.4.5 Paper Making

The following are the recommended techniques for pollution prevention and cleaner production in paper making processes. These recommendations can be grouped in two categories: general recommendations and pollution control practices.

General Recommendations:

- ☐ Upgrading of stock preparation plants with decreased energy consumption and emissions.
- ☐ Water management and minimizing water usage for different paper grades
- ☐ Recovery and recycling of coating-color containing water
- ☐ Separate pre-treatment of coating wastewater
- ☐ Measure to reduce frequency and effects of accidental discharges
- ☐ Automation of process control
- ☐ Substitution of potentially harmful substances
- ☐ Optimization of de-watering in the press section of the paper machine
- ☐ Energy savings through energy efficient technologies
- ☐ Use of combined heat and power generation

Pollution Control Practices

- ☐ Control of potential disadvantage of closing up the water
- ☐ In-line treatment of white water by use of membrane filtration
- ☐ Installation of low NO_x technology in auxiliary boilers
- ☐ Wastewater treatment, including:
 - Equalization basin and primary wastewater treatment
 - Aerobic biological treatment
 - Chemical precipitation
 - Pre-treatment of sludge

5.5 Description of cleaner production techniques

The main options for cleaner production and/or pollution prevention in kraft pulping processes are herein explained. These options are classified according to the relevant process as previously explained in Chapter 2.

5.5.1 Raw Materials & Chemicals

Chlorine Dioxide Substitution: The substitution of chlorine dioxide for elemental chlorine as a bleaching agent is gaining widespread use due to its beneficial impacts on pulp and effluent quality. The use of chlorine dioxide in place of chlorine increases the proportion of oxidative reactions thereby reducing the formation of residual chlorinated organic pollutants. The use of chlorine dioxide, however, is two to four times more expensive than the equivalent oxidizing power using elemental chlorine.

5.5.2 Washing and Screening

Improved Brown-stock and Bleaching Stage Washing: Improved washing can reduce the required amount of bleaching chemicals and the subsequent reductions in chlorinated compounds as well as conventional pollutants. State-of-the-art washing systems include atmospheric or pressure diffusion washers, belt washers, and pulp presses. Effluent flows and water use in the bleaching plant can be reduced by counter current systems. Acid filtrates from hypochlorite or chlorine dioxide stages can be used as dilution and wash water for the first bleaching stage. Similarly, second extraction stage filtrates can be used as dilution and wash water in the first extraction stage.

5.5.3 Delignification

Extended Delignification. Extended delignification further reduces the lignin content of the pulp before it moves to the bleach plant. Because the amount of bleaching chemicals required to achieve certain paper brightness is proportional to the amount of lignin remaining in the pulp after the pulping process, extended delignification can reduce the amounts of bleaching chemicals needed. The developed processes involve: increasing the cooking time; adding the cooking chemicals at several points throughout the cooking process; regulating the cooking temperatures; and carefully controlling the concentration of hydrogen sulfide ions and dissolved lignin. Applying this approach would result in marked reduction of

lignin content of the brownstock pulp, chlorinated compounds generated during bleaching and wastewater pollutants e.g. BOD₅, COD and color.

Oxygen Delignification: Oxygen delignification also reduces the lignin content in the pulp. The process involves the addition of an oxygen reactor between the kraft pulping stages and the bleach plant. The brownstock pulp from the digester is first washed and then mixed with sodium hydroxide or oxidized cooking liquor. The pulp is fluffed, deposited in the oxygen reactor, steam heated, and injected with gaseous oxygen wherein it undergoes oxidative delignification. The pulp is then washed again to remove the dissolved lignin before moving to the bleaching plant. Oxygen delignification can reduce the lignin content in the pulp by as much as 50 percent resulting in a potentially similar reduction in the use of chlorinated bleaching chemicals and chlorinated compound pollutants. In addition, the effluent from the oxygen reactor can be recycled through the pulp mill recovery cycle, further reducing the non-pulp solids going to the bleaching plant and the effluent load from the bleach plant. The net effect is reduced effluent flows and less sludge generation.

Ozone Delignification: Ozone delignification (ozone bleaching) is now being used in the pulp and paper industry. The technology has the potential to eliminate the need for chlorine in the bleaching process. Ozone delignification is performed using processes and equipment similar to that of oxygen delignification. Oxygen delignification and/or extended delignification processes are considered a prerequisite for successful ozone bleaching. When used in combination, the two processes can result in a high quality bright pulp that requires little or no chlorine or chlorine dioxide bleaching. Overall emissions from the combination of the oxygen and ozone processes are substantially lower than conventional processes because effluents from each stage can be recycled.

5.5.4 Bleaching (Optional)

Oxygen-Reinforced/Peroxide Extraction: Oxygen-reinforced extraction (oxidative extraction) and peroxide-reinforced extraction processes used separately or together have been shown to reduce the amount of elemental chlorine and chlorine dioxide needed in the bleaching process while increasing the pulp brightness. Gaseous elemental oxygen (in the case of oxygen-reinforced extraction) and aqueous hydrogen peroxide (in the case of peroxide extraction) are used as a part of the first alkaline extraction stage to facilitate the solubilization and removal of chlorinated and oxidized lignin molecules.

Improved Chemical Controls and Mixing: Avoiding excess concentrations of chlorine-based bleaching chemicals within reactor vessels can minimize the formation of chlorinated organics. This can be accomplished by carefully controlling the chemical application rates and by ensuring proper mixing of chemicals within the reactor. Modern chemical application control and monitoring systems and high-shear mixers have been developed which decrease formation of chlorinated organic compounds.

5.5.5 General Recommendation

Black Liquor Spill Control and Prevention. Spills of black liquor can result from overflows, leaks from process equipment, or from deliberate dumping by operators to avoid a more serious accident. Spills of black liquor can have impacts on receiving waters, are a source of air emissions, and can shock the microbial action of wastewater treatment systems. Black liquor losses also result in the loss of the chemical and heat value of the material. The elements of an effective spill control system include: physical isolation of pieces of equipment; floor drainage systems that allow spills to be collected; backup black liquor storage capacity; sensors that provide immediate warning of potential or actual spills; and enclosed washing and screening equipment.

5.6 Pollution prevention options in Egypt

Environmental audits for the existing mills in Egypt have shown a very high potential for improved environmental performance, reduced consumption of water, chemicals and energy, and a better quality of the final product. Preliminary cost analysis for some cases indicated that a considerable number of the opportunities have a relatively short payback period. Waste minimization and improved process control could obtain most of the technical and financial benefits. Also, effective wastewater treatment facilities would markedly reduce water consumption and increase the yield. Examples of the recommended pollution prevention and cleaner production options are herein presented. These options are classified according to the relevant process as previously explained in Chapter 2.

5.6.1 Pulping

Increase the consistency in the pulper. The tendency in paper recycling industry is to increase the consistency in the pulper to increase the throughput productivity. The pulping in such facilities is conducted at a consistency range of 4% - 6%. However, advances in this field increased consistency to a value in the order of 16%. The existing consistency is very low (2.5%). Therefore, a resultant increase in throughput productivity can be achieved and the efficiency of the pulping process will be improved.

Add Caustic Soda (NaOH) to pulper. Most of the recycled waste paper being used in the pulping process is contaminated. Addition of caustic soda in pulping process is known to improve separation and removal of contaminants. Therefore, addition of caustic soda will markedly improve the quality of the final product. Determination of the proper amount and concentration of caustic soda are subject to experimental investigation.

Add dispersant in the pulping process. In the existing process, the paper being contaminated with ink is not separated for special treatment (de-inking). The use of a proper dispersant will break down inks and colors for easy removal of such contaminants in the water clarification process. The use of the dispersant at the proper amount will improve the quality of the final product and enables efficient reuse of the clarified water.

Install a steam sparger to increase the pulping temperature. The pulping process is performed at the ambient temperature, about 23 °C. The practice in paper recycling industry shows that the higher pulping temperature, the better and faster pulping and easy removal of contaminants. Practically, the pulping temperature can be increased up to 70 °C, by installing a steam sparger. The proper operating temperature can be experimentally determined through simulated lab tests.

5.6.2 Screening and Cleaning

Re-pipe screens to be ahead of cleaners. Screens are used to remove contaminants by size, according to the size of holes in the mesh whereas; cleaners remove contaminants according to their density. Cleaners are usually operated at comparatively lower consistency levels, i.e. higher load volumes. In the existing system, the screening process is performed after the cleaning process, for the diluted liquor. This overloads the screens and adversely affects screening efficiency. Re-piping of the screens to be ahead of the cleaners will reduce its volume load and improve screening efficiency. In practice, liquor is cleaned by removing contaminants of big sizes using screens and then, removing contaminants by density.

Change to a 3-stage cascade cleaning system. The cleaning process is performed by a single stage system. It is recommended to modify the existing system to a 3-stage cascade system, with second stage accepts to broke chest and third stage rejects to sewer. The new system has a higher efficiency in recovering the fibers from the rejects and saves 90% of the losses in the cleaning process.

5.6.3 Thickening

Improve water removal in the decker thickeners. Decker thickeners are being used in the factory in order to increase consistency by removing water. Samples of the liquor before and after thickeners indicated low and unstable operating efficiency. This is because of the plugging of the screens due to scale precipitation. The following process changes were recommend in order to improve the efficiency of water removal for better utilization of this water. In addition, the resulting improvement in water dilution will improve the product quality and increase throughput productivity.

- Install a vacuum leg to increase rate of water removal.
- Re-pipe the delivery of decker thickener to before pressure screens and cleaners.
- Collect water from decker to saveall.

5.6.4 Paper Drying

Dry to the maximum specified moisture content. The moisture content in the final product was specified to be 8 - 9%. The assessment indicated that the final product is over dried and the lab showed that the moisture content is 6.5%. It is known that the yield proportionally decreases with the decrease of moisture content, in addition to the increase in energy consumption. Controlling the drying process to the higher specified limit of moisture content will also help in avoiding over-drying due to the expected temperature rise in the system because of the continuous operation.

5.6.5 General Recommendations

Eliminate contamination for counter-current flow. The counter-current flow of water is one of the main waste minimization techniques being used in paper recycling industry. In other words, water is flowing in such a way that the dirtiest water is used at the early stages of the production while the cleanest water is used in the final stages of the production. In practice, two loops are considered. The hot loop including decker thickener, clarifier and pulper, as well as the machine loop which involves showers and fresh water into felt showers and white water for illusion of cleaners. Applying this concept will markedly reduce water consumption, fiber losses and chemicals consumed.

Use proper chemicals for efficient use of water. Chemicals are being used in paper recycling plants for improved equipment operation, better product quality, and reduced water consumption. Proper selection of chemicals would help in achieving these objectives. The following are the recommended chemicals.

- Treat shower water by adding inhibiting and cleaning chemicals. This would improve operations of felts and increases the throughput productivity, by shortening formation time, for prolonged service times.
- Use proper sequestriant in the fresh water tank. This would improve the operation of equipment by preventing scale formation that plugs screens.
- Use proper chemicals (polymers) in the saveall air floatation system. This would improve removal of inks and other contaminants. Consequently, the product quality will improve and the recycled water will increase.

Optimize operating parameters of the key processes. The quality of the final products, as well as the overall productivity of a recovered paper recycling plant is much dependent on the operating parameters of some key processes and/or equipment. The following are the identified areas to be considered by the plant management.

- Improve the cleaning efficiency by optimizing delivery pressure, number, size, and configuration of shower nozzles.
- The discharge of sealing water with respect to the condition of the sealing, replace if necessary.
- The feed and reject rates of the cleaners for optimum cleaning and minimum fiber losses.
- The size of the slots in the screens.
- The rejection timing (frequency and duration) of the high-density cleaners.
- Optimum pulp refining as related to the specified strength of the final product.
- The negative pressure (vacuum) in the forming and drying processes.

6. ENVIRONMENTAL SELF-MONITORING

Self-Monitoring (SM) is a process that primarily relates to measurements of process inputs, releases and environmental pollution levels, as well as process conditions (operation controls) that are directly related to the monitored emissions. Self – monitoring is necessary for the plant to improve its economic performance by identifying the sources of wastes in raw materials, water, and energy that represent the main sources of pollution. Thus, the plant would be able to implement pollution prevention techniques that could reduce production costs and minimize compliance costs, which should lead to improved economic and environmental performance of the plant.

In addition, self-monitoring may include reporting of the results to the pertinent authorities. Monitoring can be carried out by the industrial establishment, or on its behalf, and paid for by the industrial establishment. The information obtained from the sampling component of the monitoring system must be recorded and the results reported to the appropriate internal and external decision-makers.

6.1 Benefits of SM

In general, the benefits of self-monitoring results to the operators include:

- ☐ Raising their awareness about the process performance and efficiency
- ☐ Having them ready for inspection by authorities.
- ☐ Providing inspectors with more reliable data to verify the single unrepresentative samples and/or measurements
- ☐ Raising their awareness about impact of pollutants
- ☐ Implementing corrective actions if non-compliance occurs.
- ☐ Deciding on raw materials, additives, fuels, and investment strategies.
- ☐ Identifying trends in plant performance and setting alarms.
- ☐ Improving process efficiency.

These benefits are generated through implementing an integrated environmental self-monitoring plan that comprises:

- ☐ Emission monitoring, which covers releases to air, wastewater, and solid and hazardous waste as well as regulated working conditions
- ☐ Monitoring of process parameters (operation controls) that are directly related to the releases; such as temperature, pressure, and humidity. In addition, process conditions such as shutdowns, maintenance operations, and spills need to be also monitored, linked to emissions, and reported.

6.2 Scope and Objectives of SM

As previously indicated, environmental self-monitoring comprises the monitoring of environmental releases (emissions) as well as the monitoring of process parameters (operation controls) that affect the environmental impact of the facility. The objectives of each type are separately detailed as follows:

a) Emissions self-monitoring

The basic objective of self-monitoring is to monitor compliance with environmental regulations. As the inventory for hazardous materials and wastes is mandatory with procedures for handling and storage as regulated by law 4/1994, self-monitoring should assist in covering this area. The objectives of emission monitoring may go beyond monitoring compliance; i.e. to assist improving environmental performance. In other words, monitoring of emissions at the process level is necessary to minimize emissions at the source through pollution abatement and prevention measures. While Egyptian regulations consider only concentration of the pollutants, self-monitoring may include pollution loads as well as the environmental impact on the receiving media. These data are required to assess the improvement of the environmental performance.

b) Process self-monitoring (operation control)

In most industrial facilities monitoring of process operations already exists. Some process operation controls should be monitored for improved environmental benefits. The main objectives of process self-monitoring (operation control) is:

- ☐ Optimization of process operation by controlling the operating conditions
- ☐ Minimization of losses
- ☐ Planned maintenance and repair as opposed to emergency maintenance and shutdown
- ☐ Minimization of cost through conservation of energy and water

6.3 SM and Environmental Management Systems (EMS)

Aside from the regulatory aspects, SM has shown to be a necessary tool for the plant to manage its releases, control its environmental impacts and improve its environmental performance. Such achievements represent the main objectives of the Environmental Management Systems (EMS), which in turn constitute a requirement for internal monitoring, checking and implementing the corrective actions. In addition, EMS encourages the industrial plants to adopt Cleaner Production, (CP), and Pollution Prevention, (P2), measures as the main tools for continual improvement. This can be achieved only by implementing a comprehensive and effective SM plan.

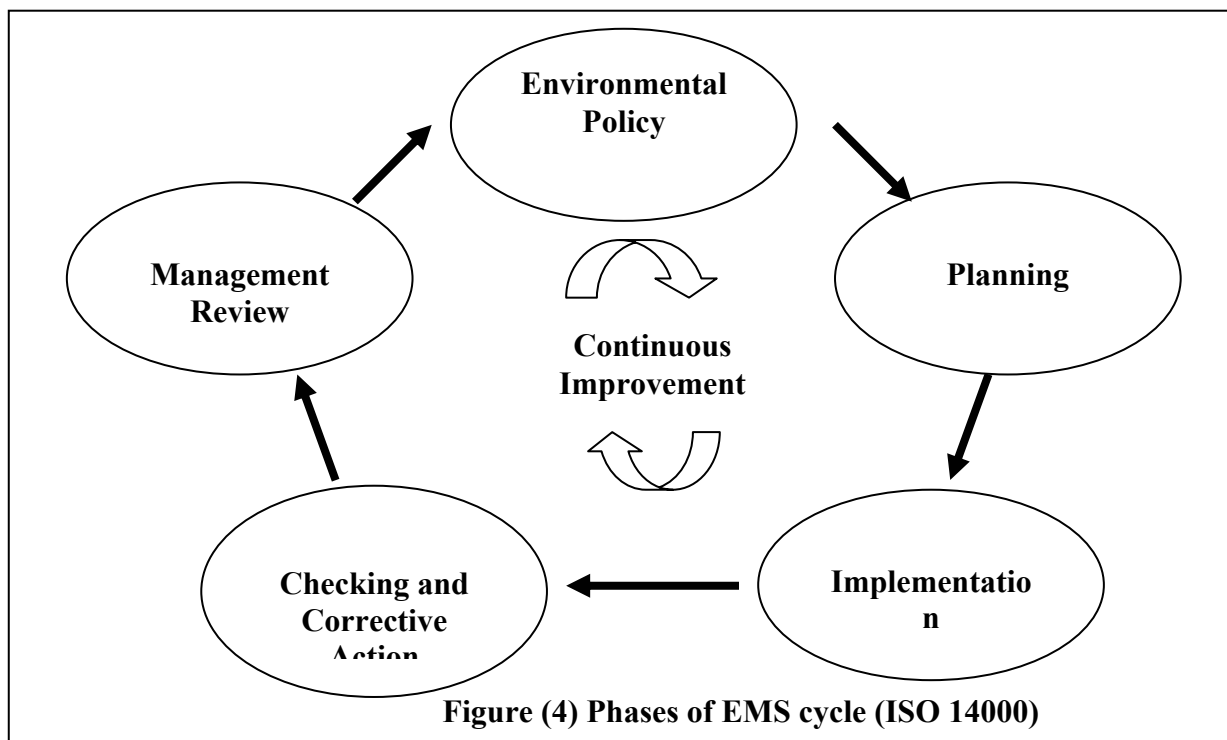
The following sections highlight the concept of EMS, link to SM and link between SM and cleaner production.

6.3.1 Environmental Management Systems (EMS)

An Environmental Management System (EMS) is a framework that helps a company achieve its environmental goals through consistent control of its operations. The EMS itself does not dictate a level of environmental performance of the company; each company tailors its EMS to its specific business goals. Compliance with environmental laws and regulations has become a major goal that has to be attained with minimum cost. This is the minimum level for environmental performance to be achieved through the EMS. In general, an EMS comprises five phases leading to continual improvement; commitment and policy, planning, implementation,

evaluation and review. These phases will be herein explained within the context of the standard system “ISO 14000”, which is internationally recognized. With regard to Egypt, this system is being gradually implemented by the Egyptian Industry. The different stages of the EMS form a cycle (Figure 4) that allows feedback of information and continuous improvement. This system includes the following elements:

1. **Environmental policy.** Top management commits to an environmental policy that comprises, as a minimum, compliance with laws and regulations, pollution prevention and continual improvement. The policy is the foundation of the EMS
2. **Planning:** The company first identifies environmental aspects of its activities. Environmental aspects are those items such as air pollutants or hazardous wastes that can have negative impacts on people and/or the environment. Once the pertinent laws and regulations are identified, the company sets objectives and targets. An objective is an overall environmental goal (e.g. minimize use of chemical x). A target is a detailed, quantified requirement that arises from the objective (e.g. reduce use of chemical x by 25% by September 2003). The final part of the planning stage is developing an action plan for meeting the targets, including schedule, resources, and the clearly defined steps to meet the targets.
3. **Implementation.** This phase comprises the establishment of the structure, assignments and responsibilities of the designated personnel. An important component is personnel training and awareness for all employees. Other steps in the implementation stage include documentation, document control, implementing operation procedure, and setting up internal and external communication lines. In addition, an emergency and preparedness plan has to be developed.
4. **Checking and Corrective Action.** The company monitors its operations and activities to ensure that targets are being met. If not, the company takes corrective action and keeps records for the emissions and environmental performance. Internal audit is a key element to improve the system.
5. **Management Review.** Top management regularly reviews the results of the evaluation to see if the EMS is efficient and effective. Management determines whether the original environmental policy is consistent with company values. The plan is then revised to optimize the effectiveness of the EMS. The review stage creates a feedback of information necessary for continuous improvement.



6.3.2 Link between self-monitoring and (EMS)

As previously explained, an EMS e.g. ISO 14000, comprises 5 stages: environmental policy, planning, implementation, checking and corrective actions. By analogy, the self-monitoring system (SMS) can be looked at using the same concept. Taking into consideration the definition, concept and principles of self-monitoring, as stated in the “Guide Book on Self Monitoring”, the elements of SMS can be rearranged as follows:

Commitment: In general, an effective self-monitoring requires that the management of the plant be committed to environmental compliance, as a minimum. However, this commitment will be an integrated part of the environmental policy in the EMS, if exists.

Planning: The planning of the SM is mainly based on objective (s) that have been set. For a basic SMS, the objective would be monitoring of regulated parameters to assist in achieving regulatory compliance; e.g. end-of-pipe emissions and discharges. In an advanced SMS, the objectives may include monitoring of operation controls as well as emissions and wastes at the source, to help in implementing pollution prevention and cleaner production measures. In all cases, the objectives of self-monitoring should be in line with the objectives of EMS, if exists. In such case, the self-monitoring plan can be part of the EMS plan and includes:

- ☐ Description of the regulatory limits for compliance
- ☐ Brief description of the actual situation (existing monitoring activities, devices, equipment, resources,..).
- ☐ Objectives and targets with time frame for implementation.
- ☐ Identification of parameters monitored, location of monitoring points and preparation of a self-monitoring schedule.

- ☐ Description of methods and procedures used for sampling, analyses, measurements, calculations, recording and data manipulation.
- ☐ Description of tasks
- ☐ Training program

Implementation: The implementation of SM means that the tools and mechanisms for collecting the relevant data are functioning. On the other hand, the implementation phase in EMS means that the environmental performance of the plant is improving. The implementation of SM results in large amount of data that need representation, interpretation and reporting in order to be useful as tools for decision making for corrective actions. The decision making requires knowledge about the status of:

- ☐ Emissions as compared to limits set by law.
- ☐ Toxic and hazardous releases: concentration, handling procedures and transfers.
- ☐ Maintenance and repair.
- ☐ Percentage losses of raw materials, products and utilities.
- ☐ Process operating parameters.

Evaluation: Evaluation of the self-monitoring plan through regular auditing will allow its continuous improvement. Evaluation should include all aspects of the plan (training, meeting targets, reliability of data, efficiency of devices,...etc). On the other hand, the evaluation of the EMS involves checking and taking corrective actions of all system components, including the monitoring activities.

Review: On the basis of the evaluation of the monitoring plan, a review can be made of the monitoring objectives and targets. In case of EMS, the management review covers all the involved procedures, including monitoring activities.

It is clear from the above explanation that self-monitoring is an integral part of any EMS. More specifically, self-monitoring is the tool for the evaluation function of an EMS. Figure (5) illustrates relationship and interaction among the main elements of EMS and SMS.

6.3.3 SM Link to Pollution Prevention and cleaner production

Growing understanding that escaping raw materials, chemicals and products constitute major pollution sources, industry has opted to implement pollution prevention measures at the source. These measures include in-plant and in-process modifications as well as resource conservation (minimization of water and energy consumption). The implementation of these measures will decrease the end-of-pipe treatment cost. However, plant management will have to undertake a cost-benefit analysis to determine which measures are economically viable.

Self-monitoring is the tool that helps undertake these analyses by providing the necessary data and information about process inputs and outputs as well as the framework for performing the required tasks. The introduction of emission monitoring for the purpose of improved environmental performance through the application of cleaner technology widens the objectives of the plant EMS beyond compliance with relevant laws and should be met with economic incentives from the part of the competent authorities.

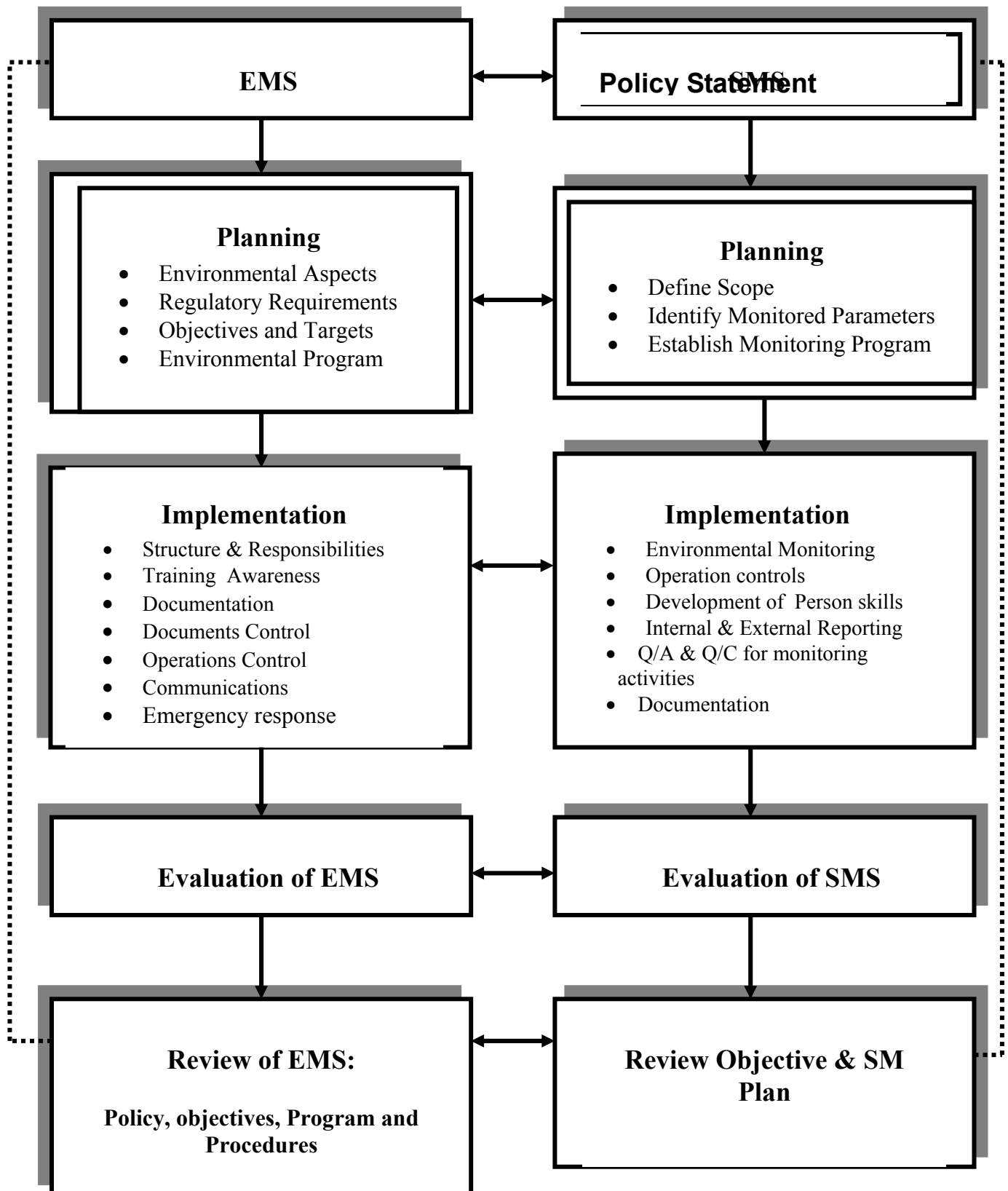


Figure 5 Relationship between EMS and SMS

6.4 Regulatory Aspects

In developed industrial countries, e.g. in Europe, the competent authorities must approve the monitoring program, specify the standards and quality requirements for self-monitoring that are to be achieved by the operator, and ensure those possibilities for cheating and fraud are minimized. The competent authorities will receive self-monitoring reports periodically from the operator. These should provide summary information, following data reduction, in a format facilitating easy comparison with permit limits. Additionally, the competent authorities would inspect the operator's self-monitoring records, including log sheets covering sampling, analyses, instrumental monitoring, and data-reduction calculations.

6.4.1 SM and Environmental Register

According to Law 4/1994, industrial facilities (operators) are required to keep a record of their inputs, outputs and releases in the environmental register as stated by which implicitly requires some sort of self-monitoring. The Egyptian Environmental Affairs Agency (EEAA) is mandated to check the validity of the data in the Environmental Register. The responsibilities of the operator and the competent authority are not affected by who carries out the monitoring. It is the responsibility of the operator to comply with laws and regulations. On the other hand, the competent authorities (inspectors) are responsible for assessing and ensuring the operator's compliance.

When combined with Self-monitoring, the Environmental Register can offer benefits to the *competent authorities* through:

- ☐ Utilizing the operator's knowledge and experience of his process in planning and carrying out a monitoring program that can lead to improved control over releases to the environment.
- ☐ Self-monitoring will normally provide more information than may be obtained by periodic inspection by the competent authorities.
- ☐ Providing a mechanism for educating the operator about the requirements for complying with relevant laws, regulations and permits and for increasing of management responsibility for compliance and the impact of process releases on the environment.

6.4.2 SM and Inspection

Self-monitoring does not constitute self-regulation. SM provides additional information on which the competent authorities can judge whether an operator is complying with relevant legislation and conditions of permits. It does not change the duty of the competent authority to assess compliance by means of inspection and by performing its own monitoring or choose to rely on the operator's monitoring data or a combination of both. The competent authority continues to be responsible for enforcement.

As mentioned above, SM provides a wealth of information that can be utilized by the competent authority in reviewing standards and developing applicable environmental policies. However, the competent authority will have to check the reliability of the SM data. Thus, inspectors may be required to check the SMS plan, QA/QC procedures, data handling and documentation. In this context, it is expected that inspectors may perform the following tasks:

- Check the SM program
- Check and verify the specified measurement standards
- Check the reliability of the data (by carrying out independent monitoring).
- Inspect SM arrangements such as:
 - The positioning and serviceability of fixed instrumentation.
 - Records confirming the maintenance and calibration of instrumentation and sampling equipment.
 - Manual sampling and analytical procedures.

This expected interaction would help both partners, i.e. the operator and the competent authority, in achieving their objectives in terms of reliability of emission data and environmental performance.

7. PLANNING OF SM

Planning for SM starts by setting the objectives. It should be clear that a number of process control parameters needs to be monitored, along with environmental monitoring. For the purpose of this manual environmental self-monitoring will be considered in addition to monitoring of process parameters that are related to emissions (operation controls).

Compliance monitoring requires measurements, analysis and data on end-of-pipe releases, whereas operation controls target the production units that offer pollution prevention opportunities. The environmental manager with the help of various sector managers should carry out the planning activities.

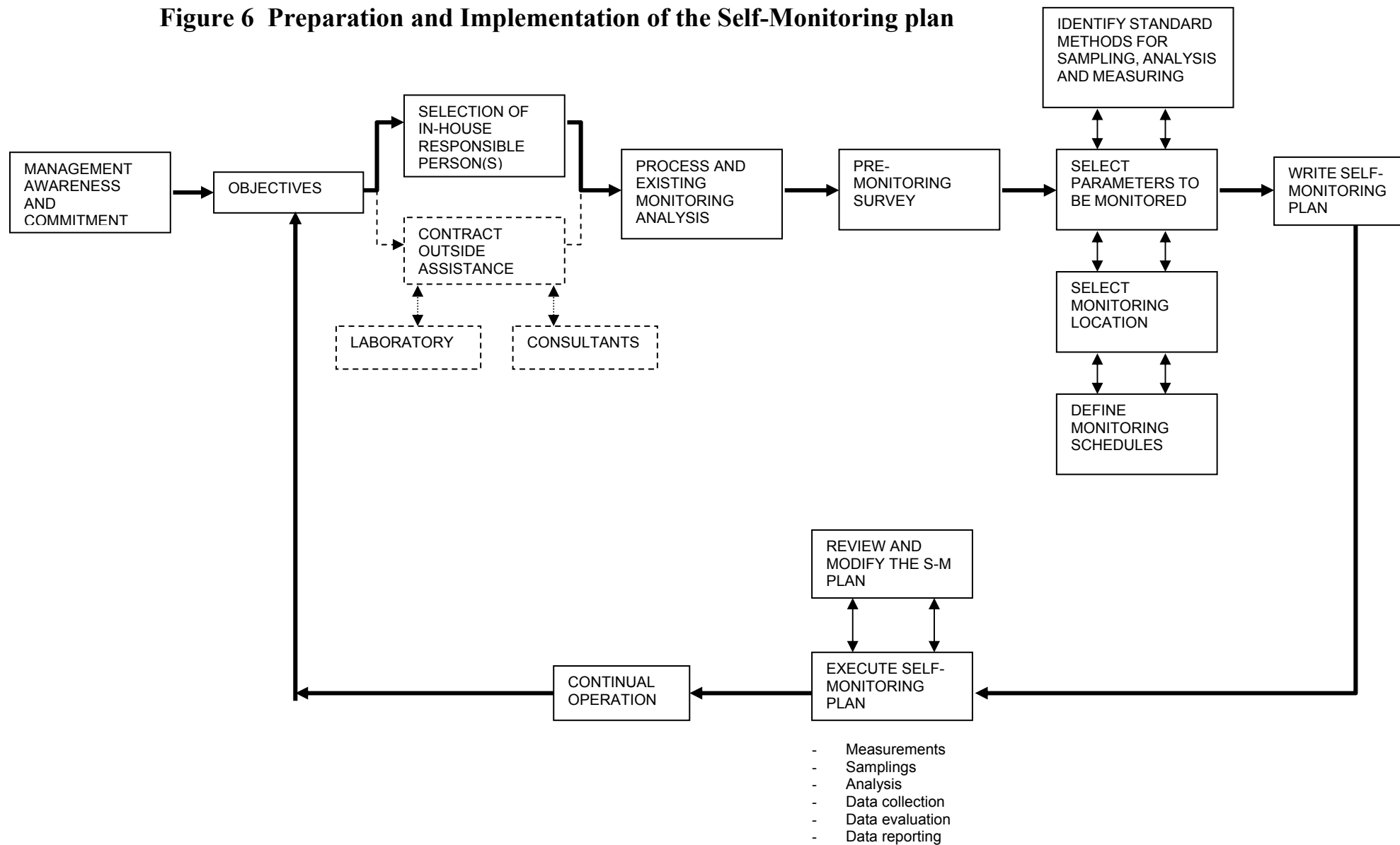
With reference to "Guidebook for Industrial Self-Monitoring", the main elements of the Self-Monitoring Plan, that describes the SMS, include:

- Objectives and results required from the self-monitoring system
- Organization and share of responsibilities and tasks
- Planning activities and design of an implementation schedule
- Definition of the parameters and relevant monitored indicators to reach the objectives
- Design of an appropriate measurement and sampling program
- Data processing and reporting procedures
- System for follow-up of decisions, actions and monitoring development
- Quality assurance and control

With reference to the Guidebook for Industrial Self-Monitoring the objective of the SMS can be limited to provide the data required for the Environmental Register, which is mandated by the Environmental Law, e.g. total inputs, outputs and emissions on the plant level. This objective "compliance with regulations" requires the "Basic Self-Monitoring System" which comprises the minimum requirements. In these cases where self-monitoring is not mandatory, operator can build a "basic" self-monitoring system that focuses on the regulated emissions, as a minimum. Then, the system can be gradually upgraded, "continual improvement" through internal auditing of all system components. Other objectives, e.g. waste minimization, pollution prevention and improved environmental performance require upgraded SMS that includes monitoring of inputs, outputs and releases on the level of operations and detailed processes. In all cases, the established SMS should be gradually improved and upgraded, considering the plant financial and economic constraints.

The following sections are detailing the stepwise activities that are needed to develop a viable, realistic, and applicable plan for a self-monitoring system. Figure (6) presents the various steps for the preparation and implementation of a self-monitoring plan.

Figure 6 Preparation and Implementation of the Self-Monitoring plan



7.1 Assessment of existing monitoring capacity

Assessment of existing monitoring capacity includes the following aspects:

- ☐ Management system: presence of an EMS, existing system for data collection and reporting.
- ☐ Human resources: available personnel, level of training; motivation.
- ☐ Technical resources: monitoring equipment and laboratory, status of equipment
- ☐ Financial resources: available budget for self-monitoring activities.

Table (5) presents an example of a checklist for existing self-monitoring activities.

Table 5. Example for assessing the status of existing monitoring activity

Monitored activity	Location	Parameter	Associated tasks	Person in charge	Frequency
Wastewater	Final discharge	Flow rate	Recording flow on flow meter Inspect meter Calibrate Data analysis, representation	Operator X Supplier Operator Y Lab staff	Daily
		BOD, COD..	Grab sample Sample preservation Analysis Review results and reporting	Lab technician Lab staff Lab staff Chief of Lab	Once a week

7.2 Identification of key parameters

The identification of key monitoring parameters requires an understanding of the manufacturing processes and the operation of the various units. The brief description provided in section 2 and the relevant tables can help identify some of these parameters. However, a pre-monitoring audit is necessary to determine sampling and measurement locations and schedules needed to design the self-monitoring plan. Priority should be given to parameters that determine compliance with environmental laws. A table describing the monitoring activities can be prepared for process and compliance monitoring.

The exact positions of the monitoring points within the production line have to be determined on a case by case basis by production experts, according to the following criteria (SM Guidebook, EPAP 1999):

- Representativeness of the monitoring point.
- Criticality of the monitoring point
- Accessibility of the monitoring points

The choice of the parameters is determined by the type of production, the legal requirements, the nature of the pollutant and its load, and the importance of the parameter for decision making. For each of the proposed parameters the trends and variations should be monitored in addition to the value of the parameter at a given time.

7.3 General Data Required

When assessing the performance of the operation and its impacts on the environment, some basic information is needed to put the monitoring data into the context of interpretation. Such information is about:

- Identification: Name, address, plant location, name of owner, manager and head of environmental department.
- Inputs name, type and amount: Raw materials, chemicals, fuels, water, steam, electricity.
- Technology: Description of process, applied technology, operating conditions (temperature, pressure), maximum capacity, operating capacity during monitoring.
- Outputs name, type and rate: Products, by-products
- Abatement techniques: Air pollution prevention, wastewater treatment, solid waste management, noise abatement
- Emissions and their sources: receiving media, pollutant type, concentration and load, pollutant impact.
- Existing EMS system, analyses and measurement results, relevant environmental laws and allowable pollutant levels.
- Assessment of legislative and regulatory requirements.

7.4 Data Collection, Manipulation and Reporting

Data collection and analysis should be carefully planned according to the following principles:

- Base the analysis on trends over a long period to take into consideration the shock loads that characterize patch processes in the Pulp and Paper industry.
- Determine the causes and degree of variability of a parameter. A dramatic change of a low-variability parameter may be interpreted as a sign of anomaly of the process. This will require an investigation to find the potential source of the problem and take the right corrective action.
- Study the correlation between different parameters. The cause of variation for a highly variable parameter may be correlated to another parameter.

A considerable amount of data may be generated by the operator carrying out self-monitoring especially when continuous monitoring instrumentation is used. Data reduction is necessary to calculate time-averaged means, percentile values and the like. When compliance data are recorded in the environmental register the relevant calculations for data reduction should be specified.

Measured values are used to form half-hourly mean values for each successive half-hour to generate frequency distribution. For each calendar day a daily mean value, related to the daily operating time, is calculated from the half-hourly mean values and kept on file. Measurement results should be kept in the environmental register for at least 10 years (Article 22 of law 4/1994 and 17 of its executive regulations). An annual report is prepared on the outcome of the measurements including information on:

- Measurement planning
- The outcome of each individual measure
- Measurement methods used
- Operating conditions that are important for the assessment of individual data and measurement results.

7.5 Criteria for selecting monitoring method.

The choice of monitoring method used to determine the value of the parameter depends on the specific features of the process, the emission sources, the physical state and properties of the sample and the nature of emissions from the operation. The latter can be classified as:

<i>Normal emissions</i>	Occur during normal operation and normal process and abatement technique conditions
<i>Diffuse and fugitive emissions</i>	These are emissions from a certain process but from scattered points such as emissions from ventilation ducts, barrels, scattered small storage's. The diffuse emissions are calculated/estimated by monitoring the source periodically and assessing the long term emission from the measurement results or by mass balance calculations.
<i>Exceptional emissions</i>	<p>Exceptional emissions refer to varying input or process conditions, start-ups, shut-downs, by-pass of a process for malfunctioning and accidental causes.</p> <p>The emissions can differ from those of normal operation in their volume and/or concentration. These emissions can be multiple compared to normal emissions. It can be impossible to measure the concentration or volume of the exceptional emissions as the measuring device is calibrated according to the normal operating conditions. Estimation techniques should then be performed.</p>

There are four basic methods that may be used to develop estimates:

- Direct or indirect measurement
- Mass balance
- Emission factors
- Engineering calculations

7.5.1. Direct or indirect measurement

a) Direct measurements: Using monitoring data or direct measurements is usually the best method for developing chemical release and/or other waste-management activity quality estimates. Data may have also been collected for the facility through an occupational health and safety assessment. If only a small of direct measurement data is available or if the monitoring data are not based on a representative sample, another estimation method should be used to give a more accurate result.

Note : Treatment Efficiencies

Supplier data on treatment efficiencies often represent ideal operating conditions, should be adjusted to account for downtime and process upsets during the year that would result in lower efficiencies. Efficiencies reported by supplier are often general and may not apply to specific chemicals. For example, an incinerator or flare may be 99.99% efficient in destroying organic chemicals, but will have 0% efficiency in destroying metals.

For successful measurements the following considerations should be satisfied:

- The frequency of measurement and sampling must cover temporal variations of the process and specifically the period during which harm occurs.
- Continuous monitoring is suitable for large emission sources, such as stacks and wastewater canals except in cases where high temperature or corrosive substances are involved. At smaller sites the cost of continuous monitoring is weighed against the value of the monitoring results and the possibility of obtaining representative results from periodic measurements.
- Utilization rate (percentage of continuous monitoring time to total operation time) should be known when performing continuous monitoring.
- The process conditions must be specified when monitoring takes place (e.g. start-up, shutdown, production rate, operating production lines, failure of abatement equipment).

b) Indirect measurements: These are performed through surrogate parameters. Surrogate parameters are variables that can be closely related to conventional direct measurements of pollutant releases or impacts and which may therefore be monitored and used instead of direct values for some practical purposes. Surrogates are commonly used in operation control as they give an early warning of possible abnormal conditions or emissions. Surrogates may provide a relative measurement rather than an absolute value and may only be valid for a restricted range of process conditions. On the other hand, surrogates can provide more continuous information than direct measurements. It is also often cost-effective as it allows more discharge positions to be monitored for the same resources. A surrogate can be used for compliance monitoring purposes if it is:

- Closely and consistently related to a required direct value (e.g. fuel sulfur vs. directly measured SO₂, relationship between opacity and particulate concentration, condenser temperature and VOC emissions).
- Regularly calibrated against the direct value.
- Cheaper or easier to monitor than the direct value, or gives more frequent information
- Capable of being related to specific limits
- The process conditions where it is measured matches the conditions where direct measurements are required.
- Any extra uncertainty due to use of surrogate is not significant for regulatory decisions or process management.

The following table summarizes the advantages and disadvantages of surrogate parameters.

Advantages	Disadvantages
<ul style="list-style-type: none"> - Cost savings - More continuous information e.g. continuous opacity vs. periodic dust sampling - Allow more positions for discharge monitoring - Sometimes more accurate e.g. fuel sulfur vs. SO₂ - Give early warning of possible abnormal emissions e.g. combustion temperature warns for 	<ul style="list-style-type: none"> - Need cost for calibration against direct values. - May provide relative measurement rather than an absolute value. - May be valid only for a restricted range of process conditions.

Advantages	Disadvantages
increase in dioxin emissions. - Cause less disruption to process operation. - May combine information from several direct measurements e.g. temperature indicates energy efficiency, emissions and process control.	- May not command as much public confidence as direct values. - Sometimes less accurate.

7.5.2. Mass balance

A mass balance involves determining the amount of chemical entering and leaving an operation. The mass balance is written as follows:

$$\text{Input} + \text{Generation} = \text{Output} + \text{Consumption}$$

- **Input** refers to the materials (chemicals) entering an operation. For example, chlorine added to process water as a disinfectant would be considered an input to the water treatment operation.
- **Generation** identifies those chemicals that are created during an operation. For example, when nitrogen sources are used in biological wastewater treatment systems, additional ammonia may be produced (generated).
- **Output** means any stream by which the chemical leaves the operation. Output may include on-site releases and other waste management activities to the environment, storage, or disposal; or the amount of chemical that leaves with the final products.
- **Consumption** refers to the amount of chemical that is converted to another substance during the operation (i.e., reacted). For example, phosphoric acid would be consumed by neutralization during wastewater treatment.

The mass balance technique may be used for manufactured, processed, or otherwise used substances. It is typically most useful for chemical that do not become part of the final product, such as catalysts, solvents, acids, and bases. For large inputs and outputs, a mass balance may not be the best estimation method, because slight uncertainties in mass calculations can yield significant errors in the release and other waste management estimates.

Material balance calculations are also used to examine the effects of emission reduction on the material balances of the plant. A material balance calculation gives an impression of the magnitude of the emission of a specific substance but cannot show accurate emission amounts, nor their division between emissions into the air, water discharges or solid wastes. Material balance calculations are often based on evaluated process flows and concentrations. Calculating of a reliable average emission level for a factory means long term monitoring of the processes and statistical examination.

7.5.3. Emission factors

An emission factor is a representative value that attempts to relate the quantity of an emission released with an associated activity. These factors are usually expressed as the weight of released emission per a unit weight, volume, distance, or duration of the activity (e.g. kg of emission released per kg of product). Emission factors have been developed for many different industries and activities. Emission factors depend on the technology used, raw materials and pollution control devices. Emission factors can be obtained from industrial databases e.g. DSS (available at EEAA).

Note

Sources of information on emission factors should be carefully evaluated and the conditions for using the factors reviewed to determine if it is applicable to the situation at the facility.

7.5.4. Engineering calculations.

Engineering calculations are assumptions and/or judgments used to estimate quantities of listed chemicals released or managed. The quantities are estimated by using physical and chemical properties and relationships (e.g. Raoult's law, Ideal gas law) or by modifying an emission factor to reflect the chemical properties of the toxic chemical in question. Engineering calculations rely on the process parameters; thorough knowledge of the operation is required to complete these calculations.

Engineering calculations can also include computer models. Several computer models are available for estimating emissions from landfills, wastewater treatment, water treatment and other processes.

8. MONITORING OF RAW MATERIALS, UTILITIES AND PRODUCTS

Data of the inputs and outputs is needed for estimating the nature and amount of the releases when assessing the reliability of the monitoring results. The input data includes the quantity and quality of raw materials, chemicals, fuel and water used.

8.1 Raw Materials and Chemicals

The amount of fiber raw material and cost/ton are important monitoring parameters. Depending on the type of fiber raw material and chemicals, the quality is assessed by the relevant parameters and tests before acceptance, Table 6. In case of discharging chemical rejects to the sewer, the flow rate should be monitored to make sure that it does not cause an increase in pollutant concentrations in the final discharge beyond limits set by law.

Table 6 Monitoring of Raw Materials and Chemicals

Parameter	Monitoring Method	Indication
Amount of raw materials (milk) and chemicals (salt, preservatives,...etc) necessary to produce 1 ton of product	Weighting, measuring, book keeping and recording	Rationality in the use of raw materials
Quantity of rejected raw material (milk) per unit of product	Weighting, measuring, book keeping and recording	Losses, process efficiency, storing or handling problems
Quality of raw material	Specific criteria (density, fat content, etc)	- Avoiding possible production problems due to bad quality - Identifying raw materials(milk) harmful for the environment if discharges to the sewer it will lead to BOD increase
Cost of the raw material necessary to produce 1 ton of product	Book keeping	Assess economical burden due to non rational use of raw material and possible avoidable extra costs
Proportion of the cost of raw material in the cost of product & its variation	Book keeping	Assess economical burden due to non rational use of raw material

8.2 Utilities

Monitoring of energy consumption takes into account the different forms of energy. It is important to note that heat and electricity cannot be summed up, as they are not commensurate. The energy efficiencies of heat and electricity should therefore be dealt with separately. See Table 7.

Table 7 Monitoring of Utilities

Parameters	Monitoring Method	Indication
Energy consumption per ton produced <ul style="list-style-type: none"> Electricity Fuel 	Consumption measurements and book keeping Fuel flow accumulator	Energy use efficiency
Repartition between the different types of energy used	Recording and book keeping	Energy use efficiency
Water consumption per ton of product produced per ton of production & and its variability	Flow measurements, book keeping and recording	Water use efficiency, most of the discharge related parameters are calculated
Quality of the utilities	According to the specific criteria	Impact on the smooth running and efficiency of processes
Steam : Pressure level Degree of saturation		
Process water : Pressure, temperature, quality		
Boiler water : Chemical quality		
Electric power : Voltage level		

8.3 Products

The most important parameters that need monitoring are presented in table 8.

Table 8 Monitoring of products

Parameters	Monitoring Method	Indication
Amount produced <ul style="list-style-type: none"> - Final product (pulp, paper, board, board products,...etc) - By- products (if exists) 	Recording and book keeping	Production statistics
Rejects as a percentage of the total production, per unit of time <ul style="list-style-type: none"> - Final product (out of specification, expired date) - in- line rejects 	Recording (quality control)	Production quality, avoidable expenses

9. OPERATION CONTROL

Processes should be operated at the optimum operating conditions to ensure the highest yield and productivity as well as product quality. Operation control deals with the control and monitoring of key parameters that affect environmental performance. These key parameters are monitored to minimize losses and therefore pollution.

Planned maintenance is also important to minimize pollution and improve environmental performance.

9.1 Monitoring process parameters

Table 9 presents the major processes in each production line and the parameters that should be monitored to minimize losses, maximizing productivity and predict maintenance needs.

Table 9 Operation Control

Production Process	Cause of Pollution	Affected Media	Parameters to be monitored	Method	Indication	Frequency/Duration
Raw Material Preparation						
Bagasse	Leaks of excess water to sewer	Wastewater	Moisture content	Sample heating and mass balance	Effluent characteristics	Twice a week
Rice straw	Particles	Air	Vacuum “neg. pressure”	Manometer	PM in air	Once a day
Kraft Pulping Operations						
Kraft pulping ¹	Discharge to wastewater Evaporation	Wastewater Work env.	pH	pH meter	Effluent characteristics Air pollution	Once/shift
Washing/ Screening ²	Discharge to wastewater	Wastewater	pH , Temp.	pH meter Thermometer	Effluent characteristics	Once/shift
O2 delignification ³	Discharge to wastewater	Wastewater	pH , Temp.	pH meter Thermometer	Effluent characteristics	Once/shift
Bleaching	Discharge	Wastewater	pH	pH meter	Effluent characteristics	Once/batch
Chemical Recovery	Air emissions	Air	Temp.	Thermometer	Air pollution	According to mode of operation
Waste Paper Processing						
Re-pulping	Discharge to wastewater Evaporation	Wastewater Work env.	pH	pH meter	Effluent characteristics Air pollution	Once/shift
Screening/	Consistency	Wastewater	pH	pH meter	Effluent characteristics	Once/batch

¹Drain to Digester floor due to valve leakage, spill of chemicals and increase of pH of wastewater.

²Accidental leakage of black liquor with increase of pH and temperature.

³Alkali liquor spill

Production Process	Cause of Pollution	Affected Media	Parameters to be monitored	Method	Indication	Frequency/ Duration
Cleaning ⁴						
Thickening ⁴	Consistency	Wastewater	pH	pH meter	Effluent characteristics	Once/batch
Paper Making						
Stock Preparation	Consistency	Wastewater	Consistency	Filtration ⁵	Effluent characteristics	Once/shift
Paper Machine	Consistency Drying Temp. Moisture content of product	Wastewater Air (energy consumption)	Consistency Drying Temp. Moisture content of product	Filtration Sample heating ⁶ and mass balance	Effluent characteristics Energy consumption	Once/shift
Utilities						
Boilers	Air emissions	Air	Air/fuel ratio Flue Temp.	Gas analyzer Thermometer	Air pollution	According to mode of operation
Wastewater treatment plant	Discharge to wastewater	Wastewater	Flow, pH, BOD, COD, TSS	pH meter Standard methods	Effluent characteristics	Continuous, Once/day

⁴Washer drain affected by spills and dilution factor.

⁵Filtration of suspended solids in wastewater.

⁶Wet and dry steam temperature and pressure.

9.2 Planned maintenance

Maintenance can be classified broadly into planned and emergency maintenance. Various types of planned activities (preventive, predictive) are undertaken with the basic objective of avoiding the need for emergency (breakdown) maintenance and the corresponding loss of plant profitability. The cost of an unscheduled breakdown resulting in loss of production can be substantial, and the cost of repairs may also be considerably higher than the cost of routine, planned maintenance of the equipment. A preventive maintenance program must include the following basic elements:

- ☐ Inventory of equipment with detailed design and operating parameters.
The operating parameters are monitored as indicators for predictive maintenance.
- ☐ A record of failure rate and causes
- ☐ Evaluation of condition of equipment using the following criteria:
 - Maintenance cost per unit of product
 - Downtime due to maintenance
 - Percent of planned maintenance hours as compared with emergency maintenance
- ☐ Determination of corrective actions.

It is clear from the above paragraph that maintenance is a pollution prevention measure as it increases the efficiency of the unit, minimizes water consumption by preventing leaks, helps conserve energy through proper maintenance of electric and mechanical equipment as well as insulation of steam pipes. Table 10 includes examples of the parameters that can be monitored. The following are examples of typical maintenance procedures for some service units operated in chemical plants:

Compressors and refrigeration systems

Routine checking should include:

- ☐ Testing for leaks
- ☐ Checking refrigerant charge
- ☐ Checking oil level and lubrication

Boilers, steam lines, heaters and dryers

There are many items to be checked to prevent explosion, such as checking operating procedures, detection of flame failure, detection of unburned combustibles. With respect to energy conservation, the maintenance of steam traps, steam valves and insulation of steam lines is important. The following parameters should be monitored:

- ☐ Water level in the boiler
- ☐ Water quality to prevent the build up of scales that reduce heat transfer rates
- ☐ Temperature of metal, gas and water
- ☐ Pressure
- ☐ Fuel to air ratio
- ☐ Check the fuel supply for leaks
- ☐ Check air supply for leaks
- ☐ Check the flue gas temperature.

Table 10 Monitoring and preventive maintenance

parameters	Monitoring method	Indication
Total number of shut downs and production interruptions	Recording	Overall assessment of the process reliability and avoided environmental loads
Number of equipment failures resulting in production shut down per type of process and type of equipment	Recording	Critical equipment
Process performance monitoring	Methods depending on the performance criteria	Process performance/ efficiency of equipment
Process equipment condition monitoring	Numerous methods, inspection, testing	Prevention of failures

10. ENVIRONMENTAL MONITORING

Environmental monitoring covers emissions to air, effluents and solid and hazardous waste. Section 4 presents the various laws and regulations that apply to emissions, effluents and wastes from the Pulp and Paper industry. Expected pollutants and hazardous releases from the industry are specified in section 2.4. Table 11 presents the compliance monitoring activities for the different aspects of pollution as per environmental laws. For each production line related pollution aspects are identified in section 2.2. The pollution aspects of service units are presented in section 2.3. The output from the measurements and analysis of the parameters are recorded in the environmental register of the facility.

Monitoring of pollutants and releases requires careful consideration of the techniques being used because due to the expected effect on the interpretation and hence, the reliability of the collected data. The common techniques used in environmental monitoring will be explained in the next sections.

10.1 Emissions to Air

Air emissions can be measured either on periodical or continuous basis.

Periodical measurements: Periodical measurements give the state of emissions over the chosen sampling time. Quantities needed in every emission calculation, such as volume flow, oxygen content and humidity of the fume, are determined by periodical measurements. Periodical measurement results are also used as a support for converting the continuous concentration measurement results into annual emissions.

Periodical measurements are carried out as manual single measurements or as short period continuous measurements by the plant itself or by an external measurer. Periodical emission measurements are carried out annually for the following emission components: NO_x, SO₂, TRS, CO, CO₂, Cl and particles, in some cases also for dioxins, HCl and furane emissions from sludge burning boilers.

Continuous measurements: The continuous measurements describe the temporal variations of the concentrations of the emission components during the operation. General requirements for continuous monitoring systems are that the sampling places should be representative and that the monitoring equipment should be suitable for the concentrations to be monitored and for the prevailing circumstances. The emission control data system should preferably be part of the process control system.

Sulfur dioxides, TRS, particles, carbon oxide are generally measured continuously.

Emission calculation: Differences between the calculational methods can cause mistakes when comparing the environmental loads of different plants. Material balance calculations are used to complete emission measurements in order to get an impression of the reliability of the measurement results as well as to create a general view of the total emission level of each component. The amount of diffuse emissions that cannot be recorded by emission measurements can be substantial.

10.2 Effluents (wastewater)

The regulations state the limits for the concentrations of some specific pollutants of the wastewater when discharged to the recipient body. For monitoring purposes, the discharge values for specific substances or parameters are mostly expressed as total amounts per unit time. In some cases these values are given as specific amounts per ton of product or as purification efficiencies. Limit values are set for COD/BOD₅, AOX, TSS, phosphorus and in some cases also for nitrogen.

Monitored control parameters: Typical wastewater control parameters include the following:

- Waste water flow (Q), m³/d
- Total suspended solids (TSS), mg/l
- Temperature, °C
- Chemical oxygen demand (CODCr), mg O₂/l
- Biochemical oxygen demand (BOD₇), mg O₂/l
- Total nitrogen (N), mg/l
- pH
- Conductivity, mS/m

Flow measurement: Measuring of the total waste water flow is required for the operation of the wastewater treatment plant. There have been no provisions on the procedure or the accuracy of a flow measurement, but installation of automatic composite samplers (preferable flow dependent) can be used. Wastewater flow is usually measured with a venturi measurement equipment, but also magnetic and ultrasonic methods are used. Measurement equipment is maintained several times a year and the measurement system is calibrated regularly.

Regular maintenance, control and calibration are needed to obtain an acceptable measurement accuracy level. Structure of the measurement system, a possible mounting fault or a false choice for measurement area cause errors. Other sources of error or factors disturbing the measurement are dirtying and temperature variations of the measuring equipment. Evaluation of the total error is extremely difficult, as it must include all these factors.

Sampling: Well realized sampling is essential for determination of wastewater discharges. There are general instructions for wastewater sampling. However, the specific problems of pulp and paper waste water sampling, caused by the variation of the wastewater quality have to be solved case-by-case, considering the operational reasons. Samples are either single grab samples, composite samples, or composite samples in proportion to the flow. A single grab sample reveals the composition of the wastewater at the sampling time. With several single samples it is possible to follow the waste water load peaks, quality variation and the easily variable parameters. A composite sample reveals the average composition over a chosen period. A 24 hour composite sample is normally taken in proportion to the flow so that the sampler is controlled by a flow meter.

Table 11a. Compliance Monitoring for Air pollution

Major pollution sources	Impact	Parameter monitored	Method used	Source type	Operating Conditions	Pollution control devices
				- Point - Diffuse	- Normal - Exceptional	
Kraft Pulping Processes						
Chemical recovery - Evaporators - Recovery boiler - Lime Kiln	Air	SOx NOx HC Particulates	Gas analyzer			Scrubber Electrostatic precipitator
Energy generation	Air	SOx NOx HC CO Particulates	Gas analyzer			
Waste Paper Processing						
Energy generation	Air	SOx NOx HC CO Particulates	Gas analyzer			
Paper/Paperboard Production						
Energy generation	Air	SOx NOx HC CO Particulates	Gas analyzer			

Table 11 b. Compliance Monitoring for Wastewater and Solid Waste

Major Pollution Sources	Impact	Parameter monitored	Method used	Source type	Operating Conditions	Remarks
				Point Diffuse	-Normal -Exceptional	
Kraft Pulping Processes						
Sources of wastewater: Pulping Washing/Screening Bleaching Chemical recovery	Receiving water body	- Organic substances (COD, BOD): - Extractives compounds like resin acids, etc. ⁷ - chlorinated organics (AOX), chlorate: - nitrogen, phosphorus: - suspended solids: - metals, salts: - colored substances:	Analysis			- <u>Raw material preparation</u> : no direct release but there is the potential for run-off of washing water. - <u>Chemical recovery</u> : wastewater mainly contains the organic in condensates - <u>Bleaching</u> : wastewater mainly contains the substances dissolved during bleaching and the residues of the bleaching chemicals.
Sources of solid waste: Raw material preparation Chemical recovery Water treatment	Landfill	– boiler ashes – dregs, lime mud – sand and stones – green liquor sludge – Raw fiber material waste – primary and bio-sludge – cleaning and mixed household type waste – others	Mass balance			<u>Raw material preparation</u> : dust, ashes and rejects. <u>Chemical recovery</u> : inorganic sludge (dregs and lime mud) <u>Water treatment</u> : inorganic material, fibers and biological sludge <u>Boilers</u> : dust
Waste Paper Processing						
Sources of wastewater Screening/ cleaning Washing, thickening and sludge handling Excess white water De-inking	Receiving water body	- Organic substances (COD, BOD) - chlorinated organics (AOX) ⁸ - nitrogen, phosphorus - suspended solids - salts - colored substances	Analysis			- Water from the papermaking machine is recycled to the de-inking process. - Whit water is recycled in the stock preparation. - Water from save-all and floatation cell is recycled to re-pulping process.

⁷ Exclude in case of bagasse and straw.

⁸ Only in case of waste paper de-inking and bleaching with hypochlorite or Cl₂

Major Pollution Sources	Impact	Parameter monitored	Method used	Source type	Operating Conditions	Remarks
				Point Diffuse	-Normal -Exceptional	
Sources of solid waste: Waste paper preparation De-inking Water treatment	Landfill	Sludge from raw water treatment - primary sludge: fibers, fillers, coating pigments - bio-sludge - rejects, de-inking sludge - ashes from steam/power generation - sludge from chemical waste water treatment				- Waste paper preparation: dust, ashes and rejects. - Water treatment (inorganic material, fibers and biological sludge) - Boilers: dust
Paper/Paperboard Production						
Sources of wastewater - Overflow from the main papermaking circuit - Press section - Overflows from tanks with poor level control - Wastewater from chemical cleaning of machine. - Washouts from chemical preparation equipment.	Receiving water body	- Organic substances (COD, BOD) - chlorinated organics (AOX) ⁹ nitrogen, phosphorus suspended solids - salts - colored substances	Analysis			Biodegradable organics. non-biodegradable organics Very low levels of heavy metals such as cadmium and mercury. Adsorbed on particulate solids.
Sources of solid waste Finishing operations		- Industrial wastes: - Not recycled broke:				- Industrial wastes, e.g. baling wires, packaging, redundant equipment, scrap materials - Not recycled broke due to colors or specialist fibers.

⁹Exclude in case of unbleached waste paper.

10.3 Monitoring of the Status of Work Environment

Major pollution sources	Impact	Parameter monitored	Operating	
			Normal	Exceptional
Kraft Pulping Processes				
Air pollution <u>Potential locations:</u> Raw material preparation Pulping Washing/Screening Bleaching Chemical recovery	Work environment	Air pollutants (according to used chemicals)		
Noise <u>Potential location:</u> Raw fiber material preparation				
Waste Paper Processing				
Air Pollution <u>Potential locations:</u> - Re-pulping - Bleaching - De-inking				
Noise <u>Potential location:</u> In the neighborhood of paper machine				
Paper/Paperboard Production				
Air pollution <u>Potential locations:</u> Finishing operations				
Noise <u>Potential location:</u> Raw fiber material preparation				

Sampling period and sample size are considered case-by-case depending on the analyses used and on the issues affecting the reliability of sampling and analyses. Samples for wastewater analysis are mostly taken over 24 hours, 5-7 days a week. In some cases samples are frozen and combined to cover a longer period. Samples for COD and suspended solids determination are taken daily or continuously and analyzed daily. Samples for BOD and nutrient determination are usually taken weekly. pH and conductivity are usually measured continuously.

Analyses: A specific analysis programme may be needed for each mill. The programme usually covers a wide range of measurements and analyses, as predetermined in the self-monitoring plan. The measurements and analyses should be carried out according to the standards recommended by the authorities.

Calculation: Wastewater discharges are calculated and reported according to the specifications determined in the monitoring plan. Discharges are often calculated as below:

Discharge per day	The arithmetic mean value of the daily samples taken during one month divided by the number of sampling days
Discharge per month	Daily discharge multiplied by calendar days
Discharge per year	Sum of the values of monthly discharges

The efficiency of biological waste water treatment is also controlled by calculating the reduction of organic matter (BOD₅, COD) between untreated wastewater before primary sedimentation and treated wastewater after secondary clarification. A typical wastewater discharge monitoring report includes e.g. monthly mean values and variations for discharges in the points of monitoring before and after the treatment, limits values in force and also some production information.

10.3 Solid wastes

The properties of solid wastes that are generated, especially when they are utilized or taken to a landfill, have to be investigated. The general principles in landfill operation are that the composition, leachability and long term behaviour and the properties of the waste have to be known. The approval of the landfilling of a waste for a certain landfill category is based on the origin and the properties of the waste. The evaluation of the properties of the waste is based on:

- the composition of the waste,
- the organic content and degradation properties of the waste,
- the content and leachability of harmful compounds, and
- the ecotoxicological effects of the waste and the landfill waters from the waste.

11. DATA COLLECTION, PROCESSING AND USAGE

The general objective for the self-monitoring system is to produce data that is representative, repeatable, reliable, compatible and comparable. These characteristics are dependent on the applied measures for quality control and quality assurance throughout the data production chain i.e. volume determination, sampling, sample pretreatment, treatment and analysis, data processing and reporting.

11.1 Data Collection and Processing

The different parts of the monitoring system of a plant include diverse factors affecting the reliability and comparability of the emission data. These factors have to be taken into consideration in sampling, sample treatment and analysis as well as in processing and reporting of the data. Requirements for the whole data production chain should be set in the monitoring program. In addition, implementation of the relevant measures for quality control and quality assurance is extremely important in obtaining maximum reliability, repeatability and comparability.

The aspects and parameters that are involved in data collection and processing are explained in the *Appendix A*. Figure 7 shows the main aspects and parameters that affect the effectiveness of SM in terms of reliability, repeatability and comparability.

11.2 Using SM outputs

The implementation of the self-monitoring plan will basically result in three outputs:

- Data and information about the facility
- Preparing the environmental register as required by law.
- Reports describing results of the self-monitoring and problems faced during implementation
- Feed back and decision making

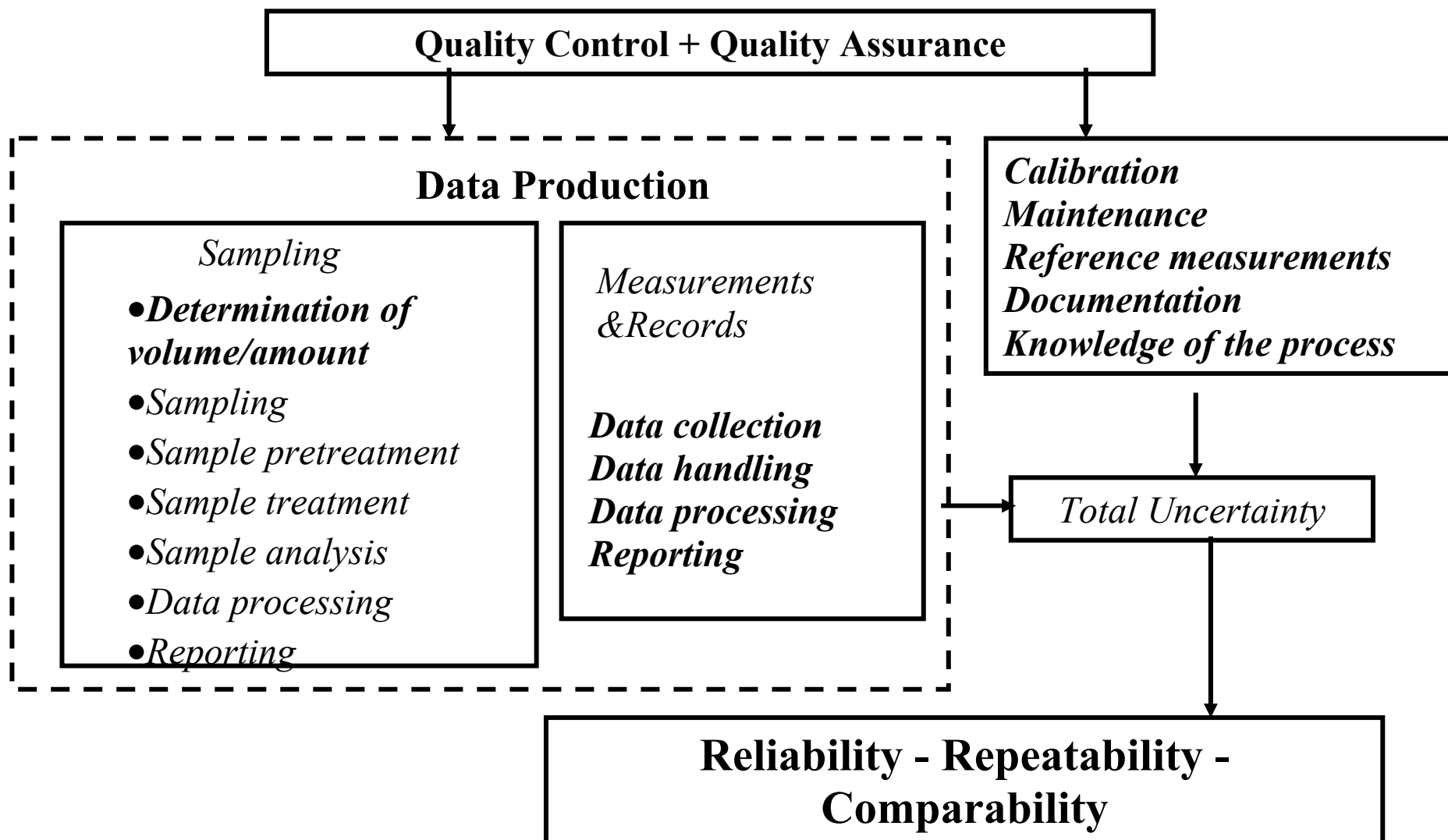
11.2.1 Techniques for summarizing and illustrating data

It is best practice to record process and environmental information in a detailed archive or database. It can then be related easily to the monitoring results and used to evaluate, compare and manage aspects of process performance such as:

- the rate of release of pollutants compared to production
- the rate of generation of waste compared to production
- the rate of consumption of energy and/or materials compared to production
- the impacts on environmental receptors compared to production or to their sensitivity
- the overall resource efficiency of the process, i.e. production compared to inputs or raw materials and energy, and outputs of pollutants and waste

There are many techniques used in the interpretation of results (e.g. statistical analysis of the measurement results, reduction of operating conditions to normal conditions when monitoring gaseous emissions).

Figure 7 Parameters Affecting SM Reliability



11.2.2 Environmental register

Only monitoring data related to compliance will be included in the environmental register. Description of the measuring and/or analytical techniques used should be reported as well as the location of sampling and measuring. EEAA/EPAP prepared a detailed description of the Environmental Register, based on the requirements of Law 4/1994, see *Annex B*. The competent authorities could request the inspection of the measuring devices to check their operability and the maintenance record for these devices. The procedures for taking samples could also be checked by the inspector. The inspectors check whether the facility has provided information that is relevant and of sufficient quality. To assess compliance, a simple numerical or statistical comparison between the measurements, their uncertainty and the limit value is performed. According to Law 4/1994, compliance self-monitoring data should be recorded and kept for a minimum of 10 years.

11.2.3 Reporting

Description of the reporting scheme, its content, recipient and purpose should be included in the self-monitoring plan. A monitoring report is a uniform presentation of data over a fixed period. An annual monitoring report that provides information of the past calendar year is always required. Shorter period reports are required for significant polluters. The conditions of the process and equipment as well as location of monitoring points should be specified. Reporting can be:

- ☐ **Internal** to inform the Management and raise the environmental awareness of the facility personnel. It should include problems met during the implementation of the SM plan to be used in decision making.
- ☐ **External** for the competent authority. Based on the environmental register, establishments are required to report on environmental violations.

11.2.4 Internal auditing and conclusions on results

The data obtained must be compared regularly with the objectives written down in the monitoring program to check that they are being met.

11.2.5 Feedback and decision making

Feedback on the assessment of compliance based on the monitoring results should include all parties involved with the monitoring activities. The participants should make the necessary improvements and corrections to the next monitoring program.

In those parts of the monitoring program where compliance is met, possible reduction in frequency of monitoring can be considered and instead move resources to parts that need more accurate monitoring, e.g. borderline or non-compliance situations. Feedback should include all parts of the monitoring program, process, product control, maintenance, environmental management and occupational safety. Detailed requirements should be set for the improvements needed and a date fixed for their implementation.

11.2.6 Using outputs in public relations

The monitoring data is refined and distributed to the end users such as national and international reporting, research and statistical purposes, citizens, and the media.

The citizens have the right to present complaints about the health or environmental impacts caused by the operation these complaints are directed to the permitting and supervising authority.

Monitoring data is needed e.g. in national research and statistics, for planning and evaluation purposes, by national group organizations and the media.

Annex A

Data Collection and Processing

Annex A

DATA COLLECTION AND PROCESSING

The general objective for the self-monitoring system is to produce data that is representative, repeatable, reliable, compatible and comparable. These characteristics are dependent on the applied measures for quality control and quality assurance throughout the data production chain i.e. volume determination, sampling, sample pretreatment, treatment and analysis, data processing and reporting. Data production chain is explained in Section 3.

1 Reliability

The realism and correctness of the measurement results should be assessed against the knowledge of the processes and inputs, e.g. by using mass balance calculations.

Good knowledge of the process: This is essential for achieving reliable emission data. Process input variations can include varying properties of the raw material, chemicals or fuel used in the processes, and the size of the input. The interdependency between the inputs, processes and outputs (products and environmental load) should be known to be able to assess the correctness of the monitoring results.

Total uncertainty: The results obtained from any measurement have a specific uncertainty. It is important that the uncertainty is estimated and taken into account when the results are used in process management or for regulatory purposes. For example, the measurement result $10 \text{ g/t} \pm 2 \text{ g/t}$ indicates that the uncertainty for this specific measurement is 20 % of the measured value.

Each step of the data production chain has an uncertainty and the total uncertainty of the measurement is the sum of these partial uncertainties. Uncertainty of each step of the data production chain must be known in order to be able to give the uncertainty of the final results, i.e. the uncertainty of the whole data production chain. When assessing the measurement uncertainty it is good to keep in mind that the factors causing measurement error can also affect each other.

Calibration and maintenance have to be carried out according to the relevant instructions and the management of them must be documented.

Reference measurements are carried out to certify the reliability of the measurements in practice. Results of an independent and neutral measurement laboratory are compared with the operator or consultant monitoring results. Reference measurements should be carried out regularly.

2 Comparability

Monitoring systems at the individual plants differ according to the scale, production, capacity or economic aspects of the operation. Data on necessary auxiliary measures and good documentation of the measurement procedure improves both the comparability and reliability of the results. All reference data, i.e. auxiliary measures and reference data (inputs and

outputs) should be clearly defined in the monitoring program or permit according to the nationally and internationally used standards and guidelines.

3 Data Production Chain

The different parts of the monitoring system of a plant include diverse factors affecting the reliability and comparability of the emission data. These factors have to be taken into consideration in sampling, sample treatment and analysis as well as in processing and reporting of the data. Requirements for the whole data production chain should be set in the monitoring program.

Data Production Chain: The data production chain includes the following phases:

- *Determination of volume/amount*
- *Sampling*
- *Sample pretreatment*
- *Sample treatment*
- *Sample analysis*
- *Data processing*
- *Reporting*

Determination of volume/amount: The accuracy of determination of the volume of the release has a substantial impact on magnitude of the total emissions. Variations in the volume measurement results can be caused either by variations in the flow of the emission or in the accuracy of the measurement. Measurement of volume flow or amount of the emission can be continuous, periodic or single.

Sampling: Continuous emission analysis includes sampling, sample pretreatment, sample treatment and analysis. Variations in the process or emission treatment affect also the quantity and quality of the sample. Both sampling conditions and the sampling point must be representative. Measurement of emission concentration can be continuous, periodic or single. The sample must be representative in relation to the measurement point, emission flow/amount, sampling period and time period.

Sample pretreatment: Sample pretreatment includes all treatment of the sample before it is taken to the laboratory. The need for sample pretreatment is determined by the needs to protect the substance to be determined from any changes before analysis. Usually the appropriate pretreatment method is presented in the standards.

Sample treatment: Sample treatment includes operations in the laboratory before analysis, such as dilution, concentration, pH adjustment, adding of reagents. Sample treatment is usually carried out according to standards or specific method instructions. The treatment methods used should be documented.

Sample analysis: Sample analysis includes physical, chemical or biological determination of the parameter. Figures presented in emission reporting are not always comparable, without describing the analysis methods used.

Data processing: The calculation methods for the emission data are process specific and their function is to give as true load data for the specific process as possible. The correspondences of the equations to the reality must be checked from time to time and automatically in cases of any changes having an impact on them. The following general rules for emission calculation need to be determined and used nationally to harmonize the methods:

- calculation methods for the peak of an hour, calendar day, monthly/annual means
- amount of emission data needed for calculation of the annual mean of the emission
- exceeding times, i.e. percentage of time of the exceptional emissions of the total operation time
- utilization rate for the continuous measurements, i.e. percentage of time during which the measurement system has not been available of the total operation time
- calculation formulas used for data conversion into reference conditions
- conversion factors used for data conversion between different units
- calculation methods for total emissions over a certain period

Reporting: Data reporting should include sufficient data on the parameters, pollutants and other measures that are defined in the monitoring plan. The data to be reported should be presented in the form required with all the additional information and documentation.

A **monitoring report** is a uniform presentation of the emission data over a fixed period. An annual monitoring report-providing information of the past calendar year is always required. In case of large industrial sites, shorter period reports are demanded (a monthly report or a report over 3, 4 or 6 months). Emission data must be presented in a form easy to compare with the given emission limits. The following data is needed for reporting:

- *The emission parameters and pollutants* are reported with all the relevant the reference parameters, auxiliary measures and uncertainties expressed as required in the monitoring program in one or more of the following forms:
 - Specific emissions (ton / ton of production): used for assessing performance or efficiency
 - Total emissions (t/ year) : used for assessing the environmental load
 - Concentration (mg / m³, PPM, % O₂): used for e.g. operation control
 - Flow rate (m/s): used for e.g. velocity/rate for flue gas/effluent
 - Residence time (s): used e.g. for assessing completeness of combustion
 - Temperature (°C): requirements for controlling certain exhaust pollutants.
 - Heat (W): thermal stress in the recipient
 - The *exceptional and diffuse emissions* are included in the total emissions of the period.
- *Operation control data* should be available to the authority.
- *Utilization rate* of the measurement system is expressed e.g. as percentage of the process operation time.
- *Documentation of the reference measurements.*

4 Quality control and quality assurance

Quality control is a system of routine technical activities to measure and control the quality of monitoring data as it is being produced. QC includes e.g. checking of equipment, methods and procedures, and that the monitoring system is regularly calibrated and maintained. The relevant instruments personnel and analytical laboratories should be certified under recognized schemes.

Quality assurance includes a system of reviewing the implementation of the quality system by personnel not directly involved in the monitoring process. QA reviews verify that the quality objectives are met and ensures that the monitoring carried out represents the best available results.

Guidelines for the below listed factors help to harmonize the practical factors at site level. The monitoring plan can determine the listed factors even in details. If the plant or the laboratory uses a sub-supplier in any step of the data production chain, the competence of the sub-supplier has to be checked, too. Quality system work involves the following processes:

Data production chain

Maintenance and calibration

Certification and Accreditation

Annex B

REGISTER OF ENVIRONMENTAL CONDITION

General Information:

- Name:
- Address:
- Contact Person:
- Position:
- Time Period covered by the current data:

General Description of the facility:

- Industrial Sector:
- Actual Production:
- Production Capacity:
- Products:
- Capital Investment:
- Annual Turnover:
- Number of Employees:
- Year of Start of Operations:
- Major Renovations:

Location:

- The location of the plant shown on a map describing also neighboring areas.
- Layout describing the location of the building, unit processes, storage areas and other parts of the plants of wastewater and air emission points to be shown on the layout.
- The maps should also show types of the surrounding and sensitive areas (Hospitals, Schools, Settlements, Parks).

Raw Materials:

- Use of raw materials & auxiliary materials (ton/year)
- Opening times for processes shall be reported as follows:
 1. Annual average operating time (days/year or hour/year)
 2. Weekly operating time and operating days per week
 3. Daily operating time and shifts per day
 4. Possible daily or seasonal variations
- Maximum amounts of each kept in storage
- Describe storage area
- Danger substance:

List of danger substance used

Name of substance	Annual consumption	Environmental properties (flammability,.....)

- Describe storage areas (capacities, preventive emergency, constructions, ventilation,.....).
- The method for circulation of the danger substance by (hand, windlass,.....).

Raw Water:

- Sources of raw water.
- Amounts of raw water taken per source and year.
- Use of water:
 - 1.For processes
 - 2.For lighting
 - 3.For other purposes

Laws and Legislation:

- State laws & regulations pertinent to the establishment. Attach copies of possible decisions and permits:
 - 1.Law no. 4/94 (yes or no)
 - 2.Law no. 93/62 (yes or no)
 - 3.Law no. 48/82 (yes or no)
 - 4.Law no. 137/81 (yes or no)
- Attach copies of the correspondence with EEAA & other environmental authorities.

Process Description:

- Attach copies from schematic diagrams for each unit processes.
- Describe the utilities (e.g. boilers).
- Using of raw water for each unit:

Name of Unit	Water consume

- Using of energy & fuels for each unit:

Name of Unit	Fuels consume

Gaseous Emissions:

- Describe the gaseous emissions (for each stack).
- Name of each unit giving rise to air pollution.
- Rate of gas emission (m^3/year):

Pollutants	Concentration of Pollutants mg/m^3	Limits of Law 4/94 for Combustion of Fuels mg/m^3	Limits of Law 4/94 for Emission of production processes mg/m^3	Loads of Pollutants ton/year

- This table for each stack.
- Measure the conc. of pollutants according to Annex no. 6 in the Executive Regulations of Law 4/94 if this emission generated from unit processes but if this emission generated from combustion of fuels so the measurement of the conc. of pollutants according to Article no. 42 in the Executive Regulations of Law 4/94.
- Describe all treatment facilities for gaseous emissions (estimate, material balance, individual measurement, continuous monitoring of process parameter, continuous monitoring of emissions).
- Treatment processes for gaseous emissions:
 1. Name of unit linked by the equipment of treatment
 2. Type of the equipment
 3. Describe the equipment
 4. Design efficiency %
 5. Actual efficiency %
- Pollution before & after treatment:

Conc. of the pollutants before treatment mg/m^3	Conc. of the pollutants after treatment mg/m^3	Loads of the pollutants before treatment ton/year	Loads of the pollutants after treatment ton/year

- This table for each treatment unit.
- Describe treatment, transport, and disposal of sludge from air pollution control

Wastewater Emissions:

- Attach copy show discharge points of industrial sewerage and domestic sewerage on the maps.

Wastewater Treatment Plant:

Describe wastewater treatment facilities with layouts and drawing. The following information shall be given:

- Processes flow diagram
- Machinery
- Design parameter
- The unit linked by the equipment of treatment.
- Type of treatment (initial, secondary, advanced).
- Capacity of the plant (m^3/hour).
- Type of equipment.
- Describe the treatment of sludge.
- Describe the way used for disposal of sludge.
- Loads of pollutants:

Pollutants	Loads of pollutants for income water	Loads of pollutants for outcome water

- The design efficiency (%) & actual efficiency.
- Monitoring of efficiency

Discharge sewerage:

Table for pollutants according to discharge points and discharge points after the treatment.

Pollutants	Conc. of Pollutants (mg/l)	Limits of Law	Loads ton/year

- The concentration of pollutants measure according to the annex no. 1 of the Executive Regulations of Law 4/94 if the wastewater discharge into the sea.
- The concentration of pollutants measure according to modify by Decree 9 for 1989 if the wastewater discharge into Municipal Sewerage.
- The concentration of pollutants measure according to the Article no. 61, 62, 66 of Law no. 48/82 if the wastewater discharge into Fresh water or Non fresh water.

Solid Waste Loads:

- Solid waste for each unit
- Name of each unit

Kind of Solid Waste	The Quantity of Solid Waste ton/year	Volume of Solid Waste m ³ /year	Notes
<ul style="list-style-type: none"> • Paper • Plastics • Glasses • Organic Compound • Metals • Anther Materials 			

- This table for each unit.

- Describe the waste disposal areas (total solid waste)

Kind of Solid Waste	The Quantity of Solid Waste ton/year	Volume of Solid Waste m ³ /year	Notes
<ul style="list-style-type: none"> • Paper • Plastics • Glasses • Organic Compound • Metals • Anther Materials 			

Hazardous Wastes (Article no. 28 of Law no. 4/94):

- Hazardous waste for each unit (Name of units):

Kind of Hazardous Waste	The Quantity of Hazardous Waste ton/year	Volume of Hazardous Waste m ³ /year	Notes

Working Environment:

- According to Annex no. 7,8,9 of Law no. 4/94
- Name of each unit

Pollutants	Conc. of Pollutants (mg/m3)	Limits of Law no. 4/94	Loads ton/year
<ul style="list-style-type: none">• Temperature• Humidity• Noise• Heat• Vibrations• Bacteria & Viruses• Odors• Other Emissions			

Self Monitoring of Emissions

Article no. 17 of Law no. 4/94:

- **Wastewater:**
- Parameters monitored (BOD, COD, TDS, TSS, Heavy metals,etc.)
- Sampling Location, Sampling Frequency and Time Table.

Sampling Location	Time between Samples

- Analytical Procedures:
- The person who responsible for monitoring and reporting

- **Gaseous Emission from Stacks:**
- Parameters monitored (NO_x, Sox, CO_x, CO, Etc.)
- Sampling Location, Sampling Frequency and Time Table.

Sampling Location	Time between Samples

- Analytical Procedures
- The person who responsible for monitoring and reporting

- **Working Environment:**
- Parameters monitored (dust emissions, odors, noise, etc.)
- Sampling Location, Sampling Frequency and Time Table.

Sampling Location	Time between Samples

- Analytical Procedures
- The person who responsible for monitoring and reporting

Annex C

REFERENCES

- *“Environmental Impacts of Pulp and Paper Industry”, UNEP 1996, ISBN: 92-807-1589-5*
- *Integrated Pollution Prevention and Control (IPPC), U.K:*
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- *“Data Production Chain in Monitoring of Emissions”, 1999, Saarinen K, Finnish Environment Institute.*
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