Ministry of State for Environmental Affairs
Egyptian Environmental Affairs Agency (EEAA)
Egyptian Pollution Abatement Project (EPAP)

Self Monitoring Manual

Textile Industry

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Self-Monitoring Manual

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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 provide 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 textile 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 self-monitoring manual

The self-monitoring manual for the textile 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 textile 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 textile industry. Chapter 5 gives examples of pollution abatement techniques and measures applicable to the textile 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. It is worth mentioning that there will be a frequent need of referring to other sources of information in order to plan, implement, and operate an effective and sustainable self-monitoring system. Therefore, references pertinent to subject matter will be mentioned. In addition, need may arise, in some instances where plant personnel are advised to call for external consultation in order to establish a proper, effective, and sustainable self-monitoring system.

1.2 Introduction to the textile industry

The textile industry is considered one of the greatest industries in Egypt regarding the number of labor, the value of exports, and the value of local production. This industry has been considered as an important contributor to the pollution of the work environment, and the waterways, especially the wet processes where hazardous chemicals are used.

1.2.1 Egyptian SIC code for the textile industry

There is Standard Industrial Classification Code (SIC) for the textile industry, and a sub-sector code for the textile products. The Egyptian textile industry comprises 31 public sector companies and about 3000 private sector and joint venture facilities.

1.2.2. Industry size and geographic distribution

Table (1) presents the geographic distribution of companies in the textile industry. The textile sector in Egypt consists of well over 3000 companies, ranging from the very small (employing less than 8 labors, such as many of the garment manufacturing facilities) to the very large (greater than 10,000 labors, such as textile complex including spinning, weaving, finishing, and garment manufacturing. These are both public and private sector companies. These are both public and private sector companies.

The textile industry is the fifth largest source of foreign earning; after oil, remittances, tourism and earnings from the Suez Canal. It is the second largest manufacturing sector in Egypt after food processing and represents 25% of total industrial output (excluding petroleum products).

Table1: Geographic distribution of the textile industry

Governorate	Sub-sector				
	Spinning and weaving	**Wool, natural and synthetic manufacture**	**Dyeing, printing and finishing**	**Knitting facilities**	**Garment manufacture**
Cairo	132	21	35	301	277
Alexandria	4	10	17	151	72
El-Kaliobia	305	8	16	11	29
El-Gharbeya	128	18	3	15	11
Assyut	2	-	-	2	1
El-Bohaira	19	3	2	-	-
Beni-Suef	2	-	-	-	-
Port Said	1	1	-	1	2
Giza	6	1	1	19	54
El-Dakahleya	21	-	-	27	5
Dumyat	3	-	-	-	1
Sohag	2	1	-	-	-
El-Suez	1	-	-	-	-
El-Sharkeya	2	5	2	3	7
Menofeya	3	3	1	1	1

The Egyptian textile industry is dominated by 31 large public companies. These public facilities account for 100% of spinning, 70% of weaving, 40% of knitting and 30% of the finished goods. They also dominate in terms of labour, volume of production and owned resources. There are over 3000 private sector factories which are members of the Egyptian Textile Manufacturers Federation (ETMF). There are also many small factories and workshops who are not ETME members, as well as informal workers who are not included in any of these groups. The private sector currently dominates the market in terms of knitted fabrics and ready-made goods, commonly consist of T-shirts, beach towels, sports and casual wear.

2. Description of Industry

The textile industry deals with fibrous materials in a form depending on the type of process, chemicals and other inputs, as shown in the following .

2.1 Raw material, chemicals and other inputs

tables (2-12) presents the different processes, the raw materials and products from each process and the related pollution sources.

2.1.1 Raw material for the following textile subsectors

Cotton Spinning	Raw cotton fibers, man-made fibers with specifications similar to cotton, or blends of cotton and man-made fibers. The raw fibers are supplied in bales.
Wool Spinning	Raw wool fibers, man-made fibers with specifications of wool, or blends of wool and man-made fibers. The raw fiber material is supplied in bales.
Weaving	Cotton yarns, woolen yarns, man-made yarns, blended yarns, textured yarns, stretch yarns, …etc.
Knitting	Cotton yarns, woolen yarns, man-made yarns, blended yarns, textured yarns, stretch yarns, …etc.
Nonwoven	Man-made fibers, wool fibers, or blends
Tufting	Acrylic yarns, polypropylene yarns, blended yarns with the wool-type.
Garment	Woven or knitted fabrics, from cotton, wool, man-made fibers, blends of natural and man-made fibers, interlining fabric and lining fabric, buttons, zebs, …etc.

2.1.2 Chemicals for the following wet processes

Sizing	Polyvinyl alcohol, carboxymethyl Cellulose, oils, waxes, adhesives, urea, diethylene glycol, ..etc.
Desizing	Enzymes, Sulpheric acid, detergents and alkali
Scouring	Sodium hydroxide, Sodium Carbonate, surfactants, chlorinated solvents
Bleaching	Hypochlorite, hydrogen peroxide, acetic acid.
Mercerization	Sodium hydroxide, surfactants, acid, liquid ammonium
Dyeing	Dyestuffs, auxiliaries, reductants, oxidants
Printing	Dyes (acids or alkalis), pigments, kerosene, binders, ammonia, xylenes.
Chemical finishing	Formaldehyde, phosphorus, ammonia, silicone, fluorocarbon resins, toluene, zircon salts, ..etc.

2.1.3 Water

The textile industry includes many wet processes within the production operations, such as sizing, scouring, desizing, bleaching, dyeing, finishing, …etc. These wet processes consume large amounts of water which are estimated to be at a rate of 200 liters/ kg of product. So, water is an important input to the textile industry. The required characteristics of the input water may need to treat the water in a special plant to remove hardness from water before being used in the wet processes.

2.2 Production operations

The textile industry covers the following different production processes and service units:

Production Processes	Service units
Spinning	Boilers
Cotton spinning (and blends)	Cooling towers
Wool spinning (and blends)	Laboratory
Fabric formation	Mechanical and electrical workshop
Weaving	Garage
Knitting	Storage facilities
Nonwoven Tufted carpet	Water treatment plant for water to be used in production units
Finishing	Wastewater treatment plant
Preparation for finishing (singeing, bleaching, …etc.)	Scavenging system for cotton dust
Dyeing	
Printing	
Chemical finishing	
Garment manufacturing	
Man-made fiber manufacturing	
Viscose production	
Nylon production	
Polyester production	

2.2.1 Spinning Industry

Tables (2 &3) presents the different processes, the raw materials and products for each process and the related pollution sources.

The two main technologies for spinning are explained in the following:

Cotton spinning

Figure (1) shows the production line for cotton spinning. In this line cotton from bales is processed through successive machines to be cleaned from dust, trashes and foreign matters, opened, mixed, carded, then drafted to a thin thread and twisted to produce the yarn. This line could also be used for spinning man-made fibers with characteristics similar to cotton, or blends of cotton and man-made fibers. The produced yarn is wound on large packages with conical shape on winding machines producing cone packages.

Wool spinning

Figure (2) shows the production processes for wool spinning. In this line, wool fibers from bales are scoured to be cleaned from grease, carbonized to remove the plant matter, carded, combed then drafted to a thin thread and twisted to produce woolen or worsted yarns. The produced yarn is wound on large package as final product for weaving or knitting, or for carpet production. The same line may be used to process man-made fibers of the type similar to wool, or blends of wool and man-made fibers.

Table (2) Cotton Spinning

Process	Input materials	Function (purpose)	Product	Air emissions	Effluents	Solid wastes	Work environment
Opening and cleaning	Raw cotton different man-made fibres (cotton – type), or both	Opening and cleaning cotton	Flow of cleaned and opened cotton	Cotton dust particulates	______	Fibers	Particulates, cotton dust, noise
Carding	Layer of cleaned cotton	Further opening and cleaning	Card sliver	Particulates	______	Fibers	Particulates
Combing	Card sliver	Further cleaning removing neps parallelizing the fibers	Combed sliver	Particulates	______	Fibers	Particulates, noise
Drawing	Card slivers or combed slivers, cotton , man-made, or both	Improving regularity, blending different fibers	Drawn sliver	Particulates	______	Fibers	Particulates, noise
Roving	Drawn silver	Reducing thickness, inserting some twist to strengthen resulting roving	Roving	Particulates	______	Fibers	Particulates, noise
Ring – Spinning	Roving	Drafting roving to yarn and inserting final twist	Ring-spun yarn on bobbin	Particulates	______	Yarns	Particulates noise
Open-end spinning	Drawn sliver	Drafting sliver to yarn and inserting final twist	Open –end yarn on cheese package	Particulates	______	Yarns	Particulates, noise
Cone –package winding	Ring-spun yarn on bobbin	Removing yarn defects and Winding yarn to cone packages	Finished Ring – spun yarn on cone packages	Particulates	______	Yarns	Particulates, noise

Table (3) Wool Spinning

Process	Input materials	Function (purpose)	Product	Air emissions	Effluents	Solid wastes	Work environment
Selection and Sorting	Raw wool	Classifying wool according to quality	Required quality of raw wool	Particulates	______	Wool fibers waste	Particulates
Scouring	Raw wool warm soapy water	Cleaning wool from natural grease, suint, dirt and dust	Clean wool from grease suint and dust	VOCs (solvents)	High solids, BOD,COD, grease, solvent and detergent residues neutral to high pH, temperature.	Wool fiber waste	Particulates, VOCs (from drying)
Carbonizing	Scoured wool - sulpheric acid (low concentration)	Removing vegetable matter	Wool cleaned from vegetable matter	Acid fumes	Normal pH below 7 occasional acid bath dumps	Little charred carbon residue	Acid fumes
Mixing and oiling	Pretreated wool oil	Mixed and oiled wool ready for Carding	Wool	VOCs	______	Wool fibers wastes	Particulates
Carding	Cleaned and oiled wool	Fiber separation and forming fiber rope (roving)	Wool roving	Particulates	______	Fiber waste (typically reused)	Particulates
Gilling and combing	Carded wool	Parallelism fibers, separate entanglement	Combed sliver	Particulates	______	Fiber waste (reused)	Particulates
Roving	Combed sliver	Drafting sliver to form roving	Roving (or top)	Particulates	______	Fiber waste	Particulates, noise
Spinning	Roving	Draft roving and insert twist to form yarn	Woolen yarn (without combing) or worsted yarn (combed)	Particulates	______	Fiber waste	Particulates, noise

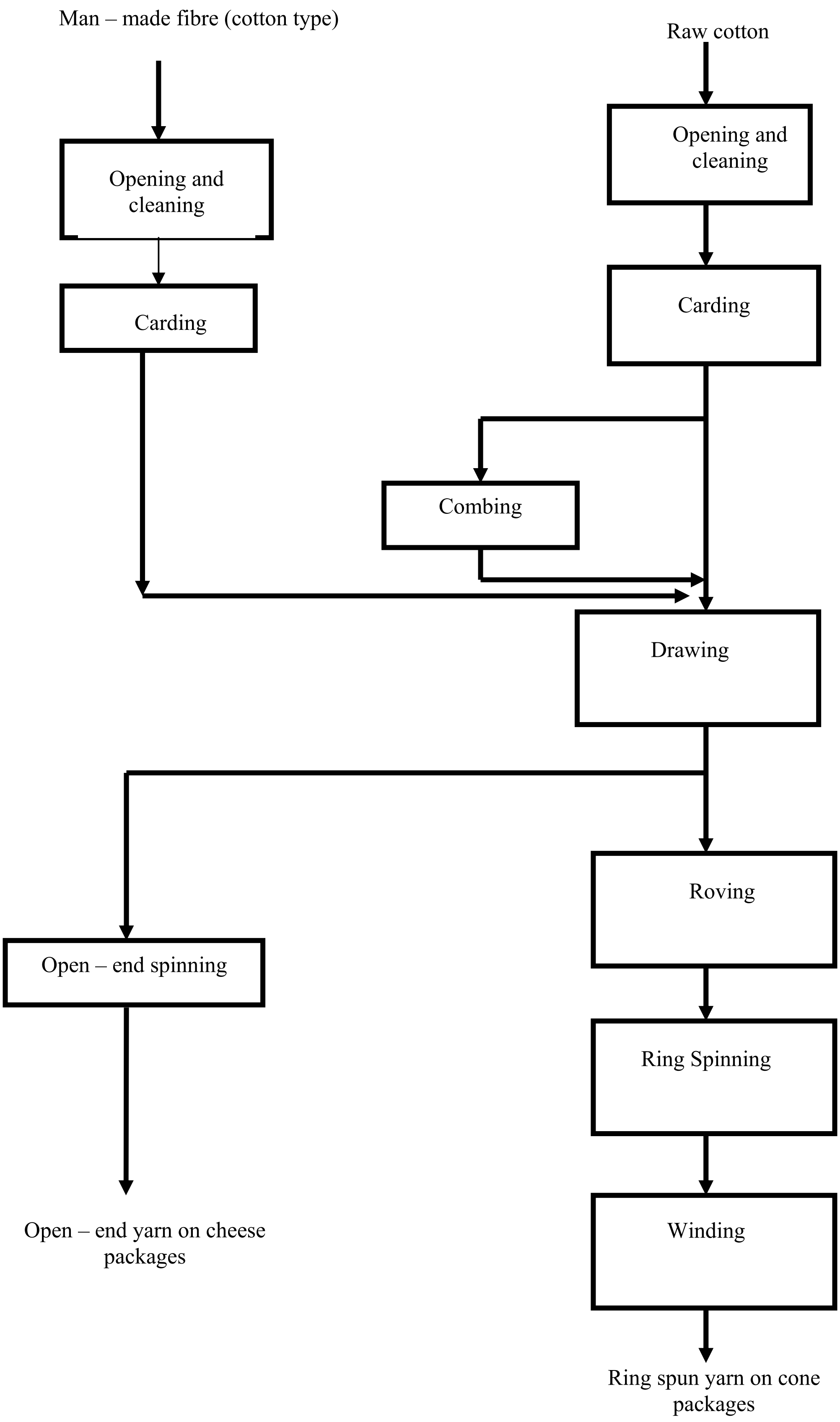


Figure (1) Production Line For Cotton Spinning System

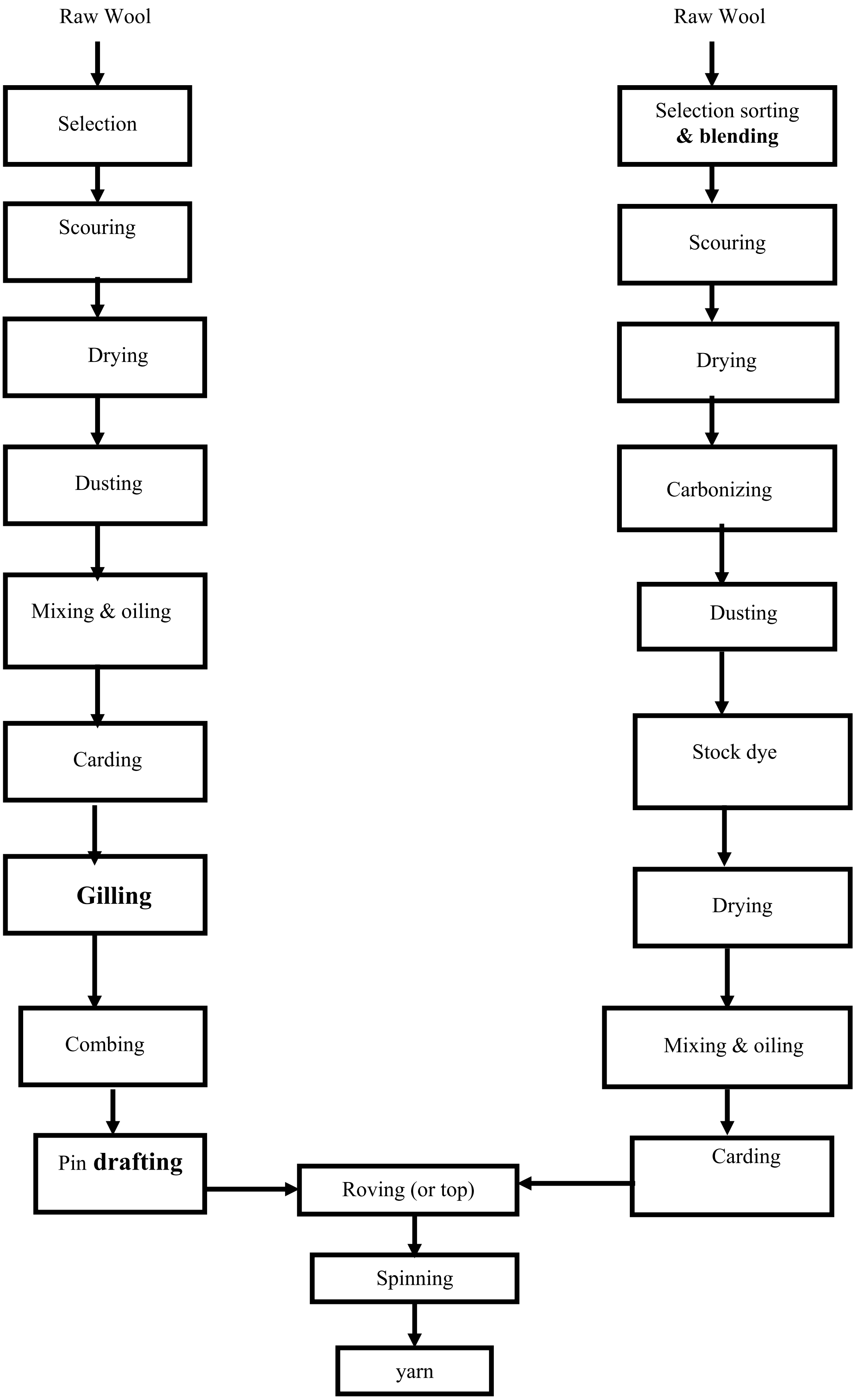


Figure (2) Wool Spinning Systems

2.2.2 Fabric Formation Industry

Tables (4 to 7) present the different processes, raw materials and products from each process and the related pollution sources.

Different processes for fabric formation are explained in the following:

Weaving Figure (3) shows the production processes for weaving yarns into fabric. In this line a large number of parallel threads are arranged with the required length, wound on a beam, strengthened and smoothed by sizing, and interlaced with weft threads on the loom to produce a woven fabric, which is wound on another beam (cloth beam).

Knitting Figure (4) shows the production processes for knitting yarns into fabrics. In both circular and flat knitting, yarn packages feed the knitting machine which forms a fabric by interlooping the threads together, using knitting needles. But in warp knitting, a large number of warp threads are arranged in parallel and wound on a beam to feed the knitting machine. The warp knitting machine forms a fabric by interlooping the threads, using knitting needles.

Nonwoven Figure (5) shows the production line for needle punched nonwoven fabric. In this line, man-made fibers are opened to form a fiber web with the required weight, then passed through the needle punching machine, where the fibers are pushed depthwise by barbed needles and get entangled, to produce a felt-like fabric with high coherence and strength. To strengthen the needle punched nonwoven, it may be treated with adhesive to give more bonding between fibers. This may be achieved by spraying the fabric with a chemical adhesive.

Tufted Carpet Figure (6) shows the production processes of tufted carpet. In this technology, the tufting machine is fed with a large number of threads, and a spun-bonded nonwoven fabric, as the ground of the carpet. The needles of the tufting machine make tracks of parallel stitches through the ground fabric, creating a terry surface. The formed carpet is back coated with adhesive resin to bind the carpet pile to the ground fabric and the adhesive is covered with jute fabric as a back. Then, the carpet surface is sheared to improve the appearance and regulate it.

Table (4) Weaving Industry

Process	Input materials	Function (purpose)	Product	Air emissions	Effluents	Solid wastes	Work environment
Warping	Yarn cones	Forming the longitudinal parallel arrangement of warp threads	Warp threads beam	Particulates	______	Yarns- packaging waste	Particulates Noise
Slashing (sizing)	- warp threads on warp beam size solution -	Treating warp threads with size solution	Sized warp	VOCs, (methanol from PVA) Particulates (from dry phases)	BOD,COD, metals, size washing residues	Fiber lint, yarn scarp size residues	VOCs (methanol from PVA Particulates
Preparing for the loom	Sized warp	Threading warp threads in harnesses, reed and drop wires to be ready for the loom	Warp beam ready for weaving	______	______	______	______
Weaving	Warp threads arrangement	Enterlacing warp threads with weft threads to from woven fabric	Woven fabric	Particulates	______	Yarn and fabric scrap	Particulates High level of noise

Table (5) Knitting Industry

Process	Input materials	Function (purpose)	Product	Air emissions	Effluents	Solid wastes	Work environment
Warp knitting: Warping	Yarns (cotton, wool, blended) man-made, filament, textured)	Preparing warp yarns on warp beam	Warp beam	Particulates	______	Yarns packaging waste	Particulates
knitting	Warp beam	Interlooping the warp yarns to from knitted fabric	Warp knitted fabric	Particulates	______	Yarn and fabric scraps, packaging waste	Particulates Noise
Circular knitting or flat knitting	Yarns cones	Interlooping threads to form weft knitted fabric	Circular knitted fabric	Particulates	______	Yarn and fabric scraps, packaging waste	Particulates Noise

Table (6) Non-woven Fabric Industry

Process	Input materials	Function (purpose)	Product	Air emissions	Effluents	Solid wastes	Work environment
Web formation	Man-made fibers (polyester, nylon, etc.)	Opening and carding the fibers	Card web of fibers	Particulates	______	Fibers	Particulates
Web condensation	Card fiber web	Condensing fiber web to required weight	Multilayer fiber web	Particulates	______	Fibers	Particulates
Needle punching	Multilayer fiber web	Mechanical bonding of fibre web	Needled nonwoven felt	Particulates	______	Fibers	Particulates Noise
Adhesive spraying and drying	Needle punched fabric	Strengthening the fabric coherence	Needle punched nonwoven fabric	VOCs	______	Fibers, nonwoven fabric scraps	VOCs, fumes of adhesive chemicals

Table (7) Tufting Industry

Process	Input materials	Function (purpose)	Product	Air emissions	Effluents	Solid wastes	Work environment
Tufting	-Carpet yarn (wool, man-made fiber) - ground fabric (spun-bonded nonwoven)	Inserting rows of tufts on ground fabric	Ground fabric tufted with carpet wool pile	Particulates	______	-Yarns - Packaging wastes. - Fabric scraps	Particulates Noise
Adhesive coating of tuft back	-Adhesive resin, - jute woven fabric	Fixing tufts to ground fabric	Tufted carpet backed with adhesive	VOCs	Chemiocals reducing the dissolved oxygen in water	Spills of adhesives	VOCs
Covering carpet back with jute fabric and drying	Woven Jut fabric and tufted carpet	Sticking the backing to the adhesive coating	Tufted carpet with finished back.	Particulates, VOCs (from resin drying)	______	Fabric scraps	- Particulates - VOCs
Shearing pile surface	Tufted carpet with solidified adhesive	Leveling the pile surface	Finished tufted carpet	Particulates	______	Fibers	- Particulates, noise

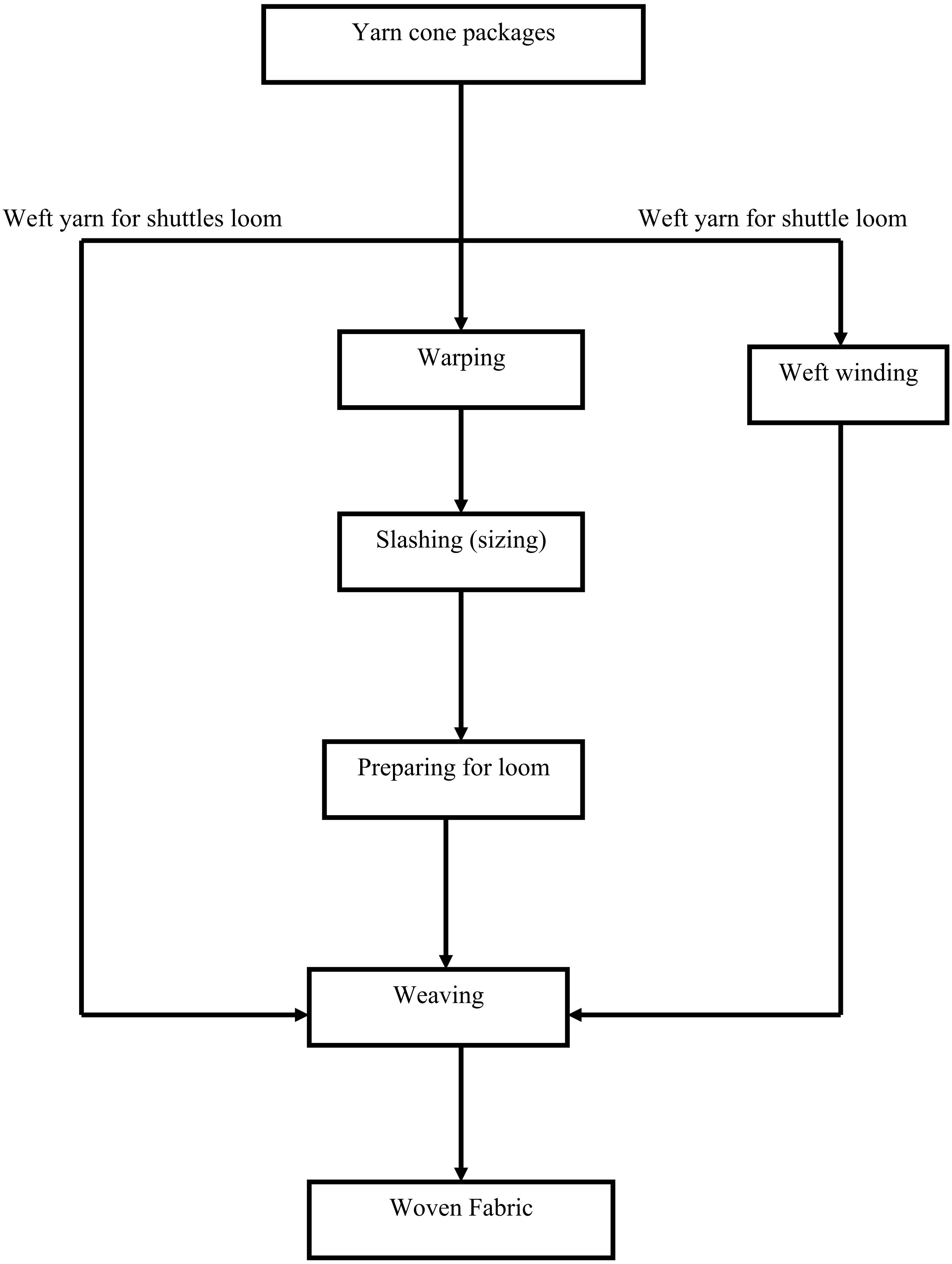
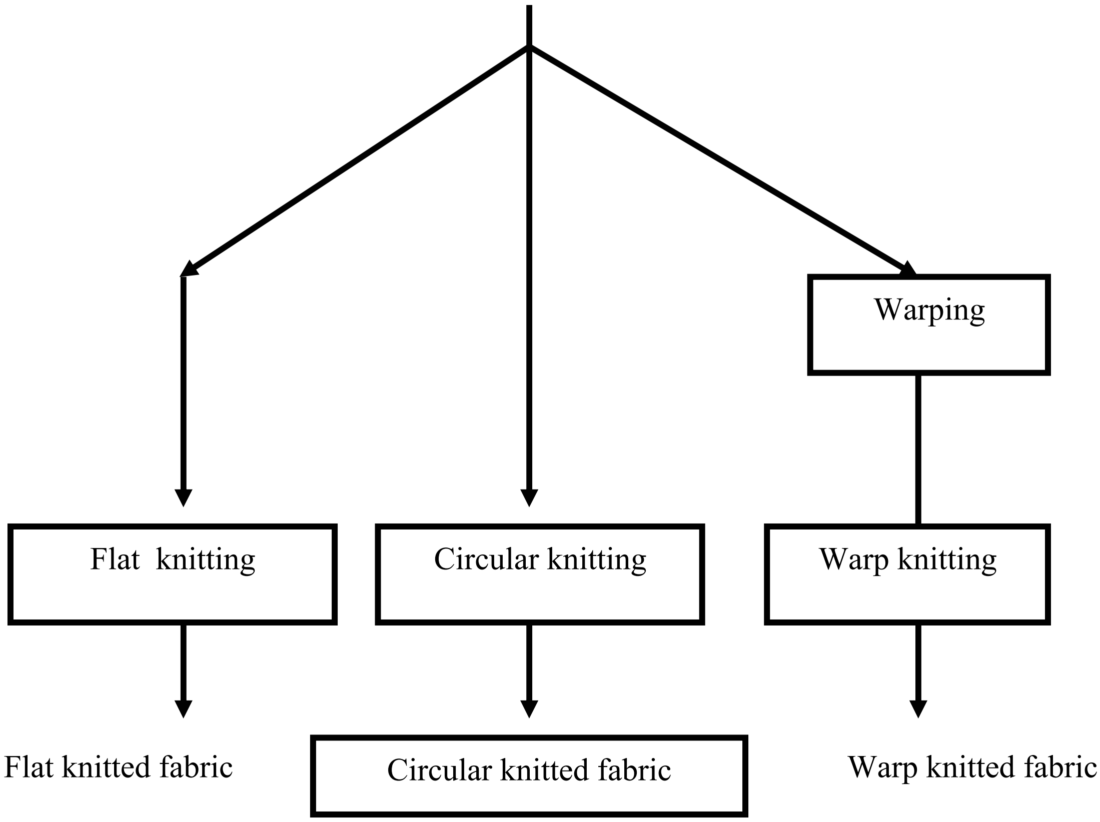
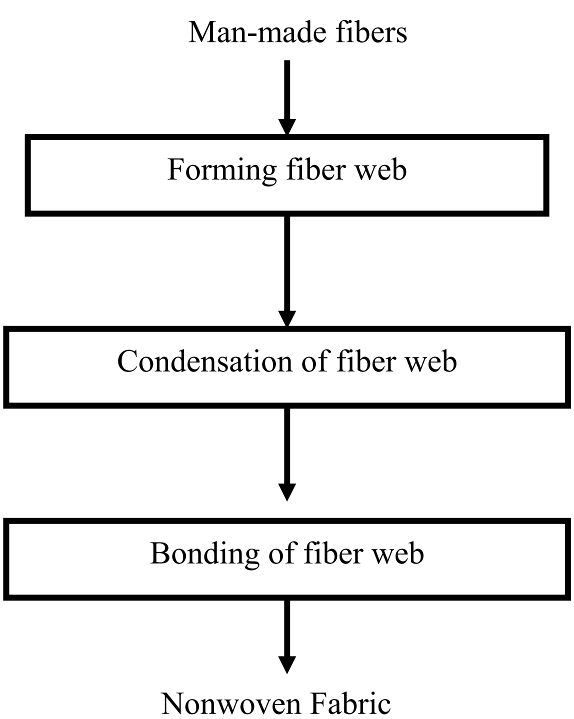


Figure (3) Production Line For Fabric Weaving



Fig(4) Production Line For Knitting Industry



Fig(5) Production Line For Nonwoven Fabric

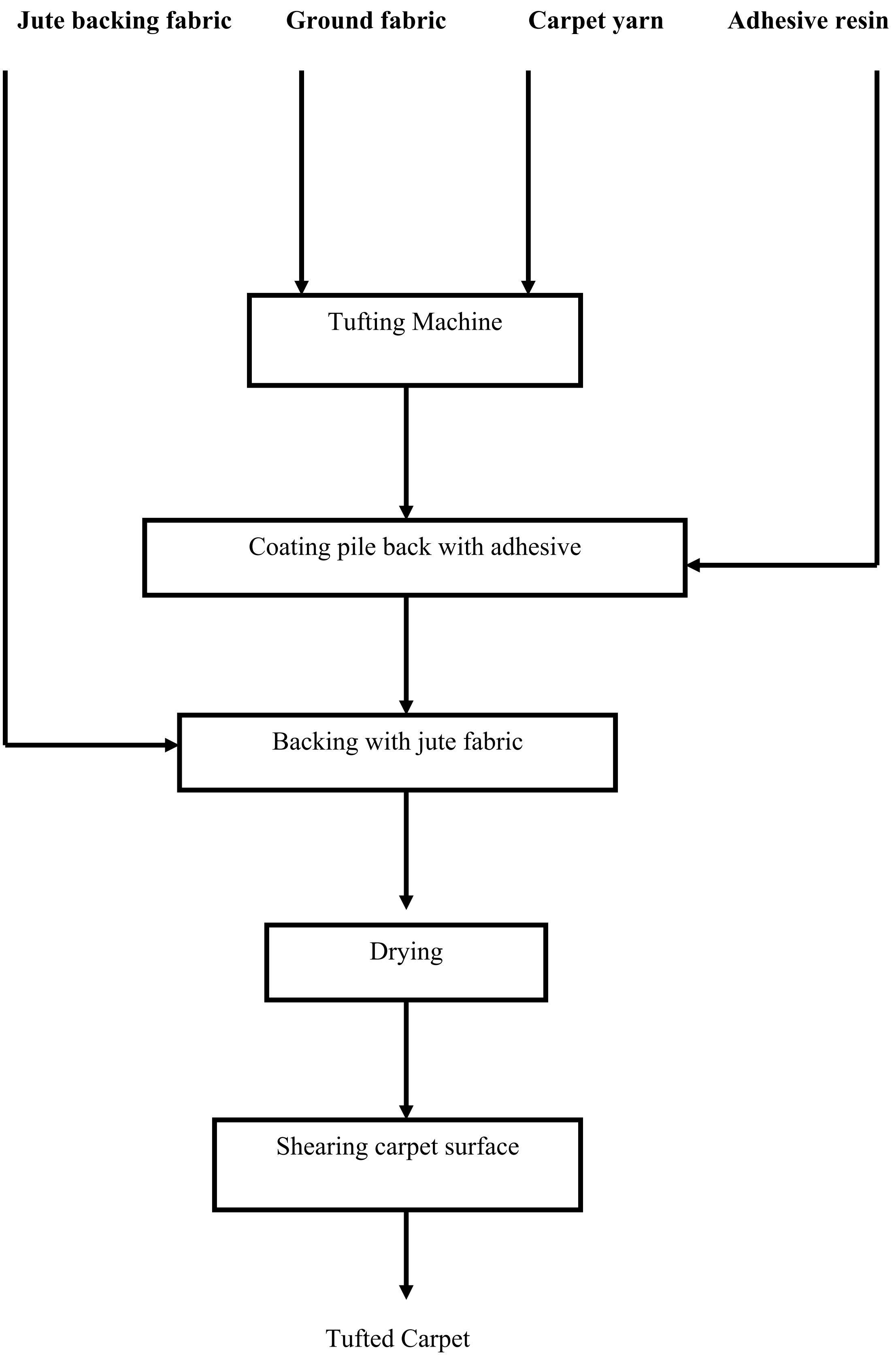


Fig (6) Production Line For Tufted Carpet

2.2.3 Finishing Industry

Table (8) gives the processes, the raw materials and products from the processes and the related pollution sources.

Figure (7) shows the production processes for finishing woven cotton fabrics and woven synthetic fabrics. Figure (8) shows the processing line for finishing cotton knitted fabrics and Figure (9) shows the processing line for finishing wool woven or knitted fabrics.

The different processes are explained in the following:

Singeing This process ***(cotton only)*** is considered one of the processes for finishing preparation, and is only concerned with cotton woven fabrics. In this process the greige fabric surface on both sides is subjected to a gas flame which burns the protruding fibers and results in a smooth surface.

Desizing In this process the size materials on the warp threads of the fabric are removed, by passing the fabric in a bath of sulpheric acid or by using enzymes, soap or hot water depending on the sizing material. This process is also considered one of the preparation processes for finishing.

Scouring In this process, the desized fabric is passed through a cleaning bath, using alkaline or solvent solutions to dissolve any impurities or soiling on the fabric.

Desizing and scouring could be done in one operation in some plants. The operation is a preparation step for bleaching and dyeing. It is possible to do desizing by using hot water and soap.

Bleaching This process ***(for natural fibres)*** is also one of the preparation processes for finishing, to obtain white colour in the fabric, by using bleaches, such as hydrogen peroxide or hypochlorite.

Mercerizing This process ***(for cotton only)*** is also a preparation process for finishing, in which the fabric is treated with sodium hydroxide to create luster, more strength and higher affinity for dyes in the fabric. This process could be applied to woven or knitted cotton fabrics.

Dyeing This process is the finishing process in which the yarn, fabrics, or garments are treated to add color and intricacy to the product, using dye stuffs, auxiliaries, reductants, oxidants, …etc. This process is well known to be a major source of pollution due to the many chemicals used, and the large quantities of wastewater resulting from the process, and loaded with pollutants.

Printing	In this process the fabric is printed with color and patterns, using pigments, dyes, acids, alkalis, softener, binder and emulsifier solvents. Printing is also one of the major sources for pollution.
Carbonizing	In this process***(for wool)***, woven or knitted wool fabrics are treated with sulphuric acid to remove the vegetable cellulosic matter naturally existing in wool fibers.
Special finishing	In the special finishing process***(moth-proofing, water repellant, stain resist, …etc.)***, the fabric is chemically treated to achieve certain characteristics in the finished fabric giving it special performance, such as water-proof, crease resistance, …etc.
Brushing and napping	This process is considered as a mechanical finishing process, in which the fabric surface is subjected to a brushing action to raise fibers from the yarns and create a hairy surface in the fabric. This process may be applied to both woven and knitted fabrics.
Shearing	This process is also a mechanical finishing process that is applied to woven fabric, to shear the protruding fibers from fabric surface and create smooth surface fabrics. This process is a sources for fiber particulates
Softening by calendering	This is a mechanical finishing process simulating, the ironing process of fabric to produce smooth unwrinkled surface. The woven fabric is passed between smooth pressed rollers to remove surface fibers and reduce friction between fibers, resulting in soft feel in the fabric
Sanforizing	This is a mechanical finishing process applied to woven fabrics to compact the structure by passing the fabric between smooth heavy rollers, and produce compacted fabrics
Addition of lustre	In this process, the woven fabric is passed through calenders with three rolls, the center one of cotton or paper, and the two outside rolls of metal. The fabric is fed around the center roll while the two outside rolls revolve on the fabric face at a very high speed and develop a polished fabric surface by friction. To make this glazed surface relatively durable, resins are used.

Table (8) Finishing Industry (Textile wet processes)

Process	Input materials	Function (purpose)	Product	Air emissions	Effluents	Solid wastes	Work environment
Singeing (cotton only)	Unfinished woven cotton fabrics.	To burn the surface fibers of greige goods to give smooth surface	Fabric with smooth surface, and no protruding fibers	Small amounts of exhaust gases from burners	______	Little or none	Small amount of burning fumes
Desizing	-Singed fabric - enzymes, - acids (sulphuric)	To remove size material from woven fabric	Fabric free from size	VOCs from glycol ethers	BOD from sizes, lubricants, biocides, anti-static compouds	fiber lint, yarn waste, cleaning materials.	VOCs (from glycol ethers)
Scouring	- Knitted, or desized woven fabric, -alkaline or solvent solutions	Cleaning fabric from impurities	Clean fabric	VOCs from glycol ethers and scouring solvents	High BOD and temperature very high pH, fats, waxes, detergents, size mix residues, solvent residues	Little or no residual waste	VOCs (from ethers or scouring chemicals)
Bleaching (for natural fibres)	Scoured fabric, hydrogen peroxide, hypochlorite	Eliminating unwanted coloured matter decolorizing coloured impurities.	White bleached fabric	Chlorine chemical fumes, acetic acid fumes	Low to moderate BOD, high pH and temperature, bleach and additives residues	Little or none	Chlorine chemical fumes; acetic acid fumes
Mercerizing	- Woven or knitted cotton fabric - caustic soda (15-20%) - acid	To give luster, more strength, and higher affinity for dyes	Mercerized woven or knitted fabric	Little or none	Very high pH, dissolved solids , some, BOD, NaOH	Little or none	______
Dyeing	Woven or knitted fabric, dye stuffs, auxiliaries, reductants And oxidants	Add colour and intricacy to fabrics	Dyed fabric	VOCs (ethylene glycol), amonia	Depending on type of dye, dissolved solids, COD heavy metals causing toxicity, BOD.	Chemical residues, fabric scrap	VOCs (ethylene glycol)

Table (8) cont. Finishing Industry

Process	Input materials	Function (purpose)	Product	Air emissions	Effluents	Solid wastes	Work environment
Printing	Woven or knitted fabric, pigments, and dyes, acids or alkalis, softener, binder, emulsifier solvents	Printing colour and patterns on fabric	Printed fabric	VOCs (e.g. ethylene glycol, urea, formaldehyde, kerosene) amonia, combustion exhausts	High COD and salt content solvents toxic metals BOD, foam, heat	Chemical residues	VOCs, ethylene glycol, Urea formaldehyde kerosene amonia, noise
Carbonizing (for wool)	Woven or knitted wool fabric sulphuric acid	Removing vegetable matter	Wool fabric cleaned from cellulosic matter	Acid fumes	Normal pH below 7 occasional acid bath dumps	Little charred carbon residue	Acid fumes, noise
Special finishing (moth-proofing water repellant stain rest, etc)	Woven or knitted fabric - Mitin, Dieldrin and Boconize for moth-proofing fluoro chemicals for water and oil repellent	Giving fabric special property	Fabric with special finish	Particulates VOCs formaldehyde combustion exhausts	BOD,COD suspended solids, toxic materials, spent solvents.	Chemical residues fabric scrap	Particulates VOCs Formaldehyde, noise
Brushing and napping	Woven or knitted fabric	Raise surface fiber and change feel and texture of fabric	Fabric with hairy surface	Particulates	______	Fiber waste	Particulates, noise
Shearing	Woven fabric	Removing surface fibers	Fabric with smooth surface	Particulates	______	Fiber waste	Particulates, noise
Softening by calendering	Woven fabric	Removing surface fibers friction between fibers	Stoft fabric	______	______	______	Noise
Sanforizing	Woven fabric	Compacting the fabric	Fabric with compressed structure	______	______	______	______
Addition of luster	Woven fabric	Adding luster to fabric surface	Fabric with Lustrous flattened and smoothed yarns	______	______	______	Noise

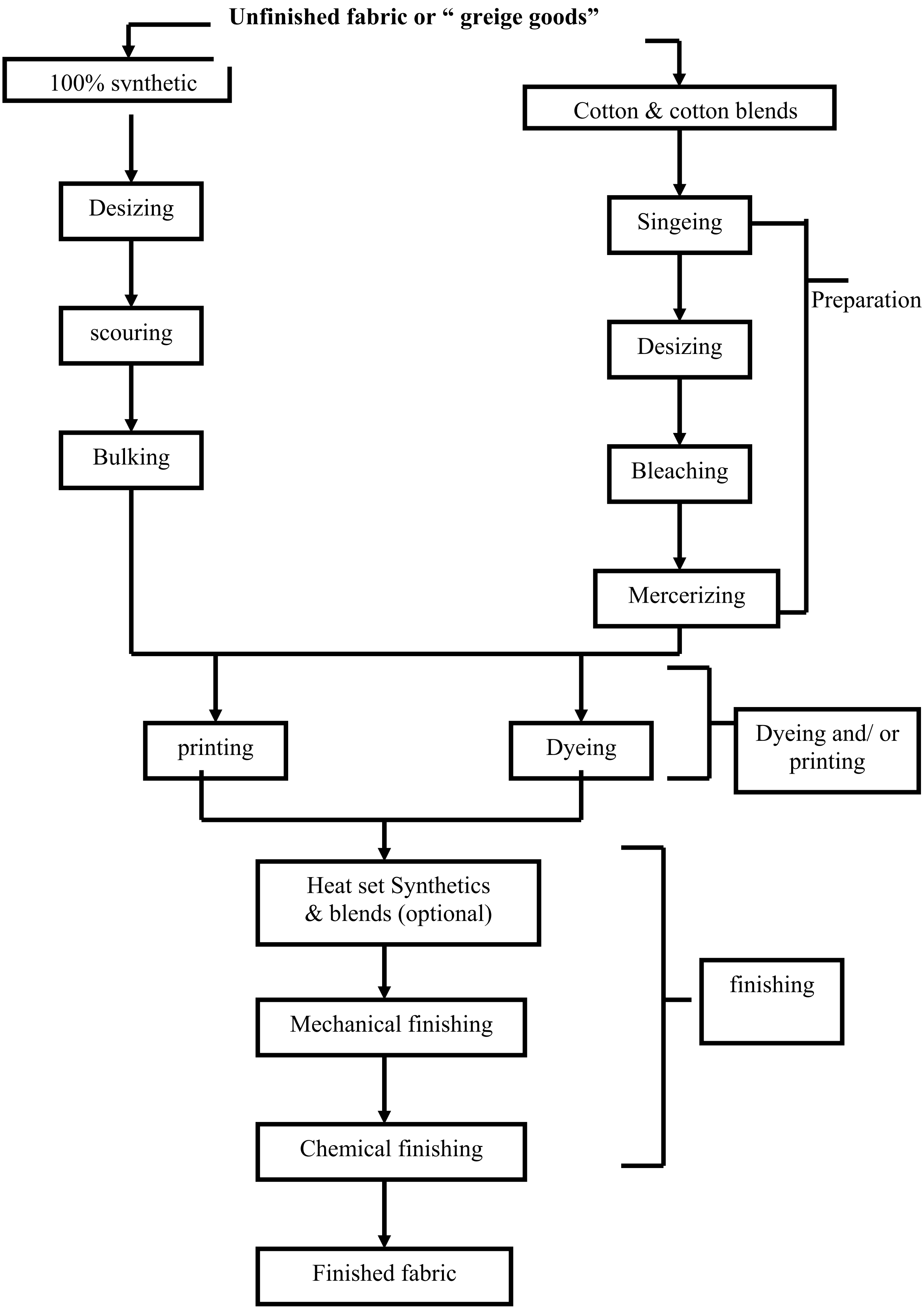
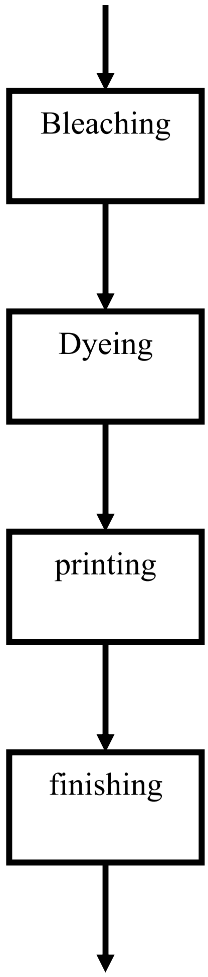


Fig (7) Finishing Of Woven Cotton And Synthetic Fabrics

Knitted Cotton fabric



Finished fabric

Fig (8) Finishing Knitted Fabric

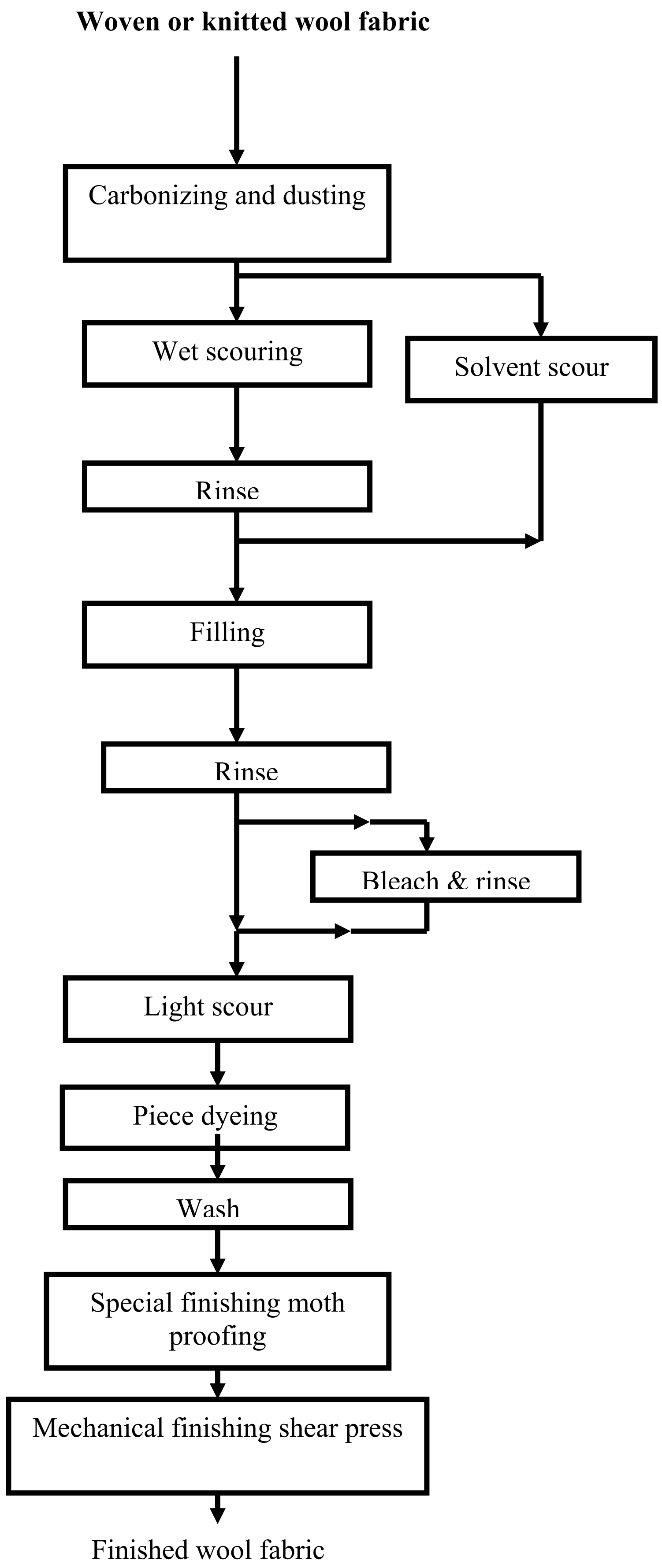


Fig (9) Finishing Wool Fabrics

Garment Industry

Table (9) shows the processes, the raw materials and the products from the processes and the related pollution outputs.

Figure (10) shows the production processes for transforming woven or knitted fabrics into garments, and are explained in the following:

Fabric laying	In this process the fabric is laid on a long table in multilayer arrangement, using a special machine with reciprocating carriage. This process is applied for the main garment fabric, and also the lining fabric.
Placing patterns	After collecting the number of fabric layers, the patterns of the garment are placed on top of the layers, and fixed by special pins.
Cutting	The multilayers are cut according to the patterns by using electric cutter which moves around the patterns to produce garment parts and, similarly lining parts and interlining parts
Sewing	In this process, the garment parts are assembled together by stitching on sewing machines. Also, the lining parts are assembled by sewing operation.
Sticking interlining	In this process, stiffening interlining pieces are heat pressed on some garment pieces, using a special heat press.
Ironing	This is a finishing process to remove wrinkles from garment and give a neat appearance
Packaging	In this process, finished garments are packed in plastic bags, then in carton boxes according to the size.

Table (9) Garment Industry

Process	Input materials	Function	Product	Air emissions	Effluents	Solid wastes	Work environment
Fabric laying and pattern placing (for garment fabric, interlining, and lining	Garment fabric Lining fabric Interlining fabric	Forming multilayer of fabric and fixing pattern on fabric	Arrangement of multilayer fabric with patterns positioned and fixed on.	_____	_____	_____	Particulates dust
Cutting	Multilayer fabric with patterns on	Cutting fabric according to patterns	Garment pieces Lining pieces Interlining pieces	Particulates VOCs from fabrics	____	Fabric scrap Lining scrap Interlining scrap packaging waste	Particulates, VOCs from fabrics and noise
Sticking interlining pieces to garment pieces	Garment pieces and interlining fabric pieces	Heat pressing interlining to fabric pieces	Garment pieces with interlining stuck on.	Adhesive fumes	______	Fabric scrap	Heat and fumes
Sewing	Garment pieces Lining pieces Sewing threads Buttons Zippers etc	Assembling each of garment and interlining, and the two together	Complete assembled garment	Particulates VOCs from fabrics	____	Yarn scrap	particulates Noise
Ironing	Complete garment	Finishing the appearance	Finished garment	____	____	____	Steam Noise
Packaging	Finished garments	Packaging garments	Different sizes of carton boxes	____	____	Carton scrap, plastic bags	____

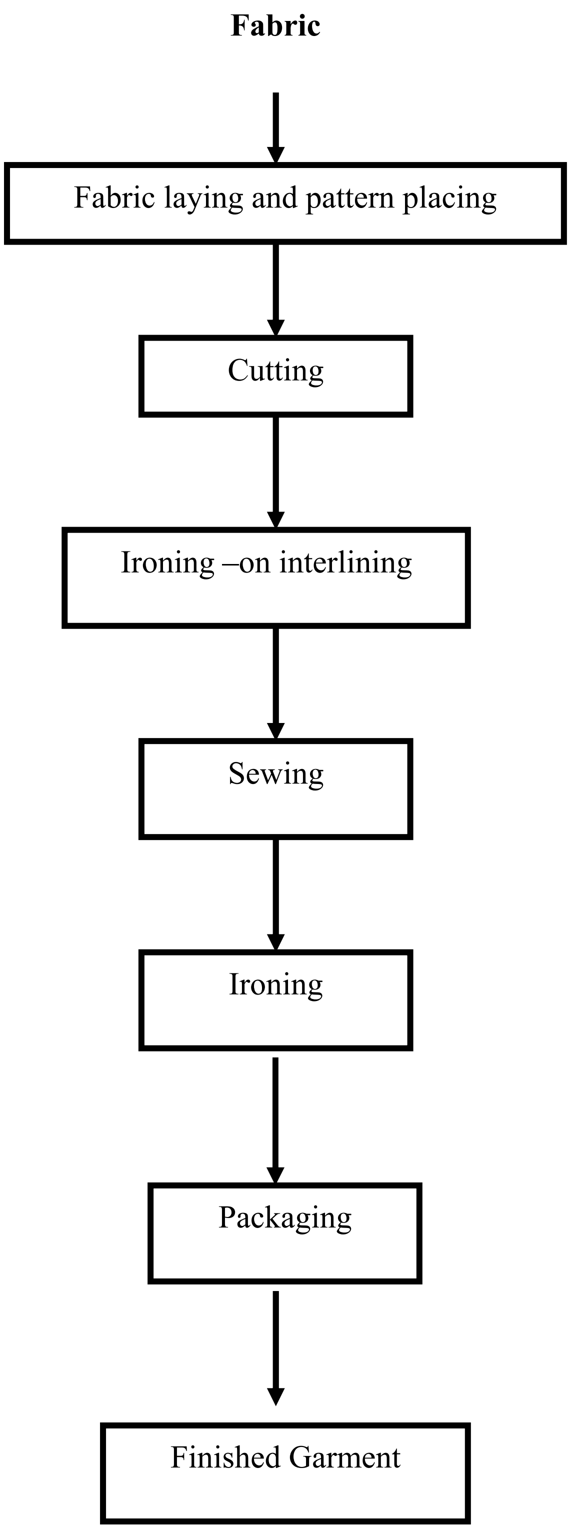


Fig (10) Production Line Of Garment Manufacturing

2.2.5 Man-made Fibre Industry Viscose Rayon

Table (10) gives the processes, the raw materials and products from the processes and the related pollution output.

Figure (11) shows the successive production processes for viscose fibers and filament yarns, as explained in the following :

Soaking in caustic soda	In this process the wood pulp is soaked in sodium hydroxide to produce soda cellulose which is squeezed to remove the extra caustic soda solution .
Shredding	The crumbs of soda cellulose are shredded to produce small flakes.
Ageing	In this process, the shredded soda cellulose is aged for a certain time to adjust the molecular structure.
Xanthating	The aged cellulose is mixed with carbon disulphide to produce by chemical reaction xanthate
Dissolving	The xanthat is dissolved in sodium hydroxide to produce xanthate solution for spinning.
De-aeration and filtration	In this process, the xanthate solution is stored in tanks under vacuum to remove any air bubbles, and is passed through multi stage filters to remove any trash particles, and when the viscose solution is ready for extrusion after a period of ageing, it is pumped to the extrusion spinnerettes
Spinning	Viscose solution is pumped to the spinnerettes, which are Immersed in dilute sulphuric acid bath, and when the solution emerges it reacts with the acid and is solidified to a continuous filament that is subjected to stretching and wound inside a rotating pot to form the viscose yarn package.
Scouring	The viscose yarn packages are scoured and washed to remove residual salts and acid.
Winding	The finished viscose filament yarn is then wound on winding machines to the required forms of packages.
Scouring and crimping	This process***(for filament tows)*** is especially for the production of viscose fibers, and is carried out on a separate production line, where the tows of continuous filaments coming out of spinneretts, are collected scoured, washed, crimped and dried.
Cutting and pressing	At this stage a layer of viscose crimped filaments transforms the filaments to fibers with length similar to cotton or similar to wool. The resulting fibers are pressed into bales as final product.

Table (10) Manufacturing of Viscose

Process	Input materials	Function	Product	Air emissions	Effluents	Solid wastes	Work environment
Soaking in caustic soda	- Purified wood pulp - Caustic soda solution	Chemical treatment	Soda cellulose	Caustic soda vapor	______	Wood pulp scrap	Caustic soda vapor
Shredding	Soda cellulose	Cutting into crumb	Crumb of soda cellulose	______	_____	Spills of crumb	______
Ageing	Crumb of soda cellulose	Adjustment of molecular structure	Aged soda cellulose	______	_____	______	______
Xanthating	Aged soda cellulose, carbon disulphide	Chemical change to xanthate	Xanthate	Carbon disulfide gasses	Cooling water	_____	Sulfide gasses
Disolving	Xanthate, sodium hydroxide solution	Disolving xanthate	Xanthate solution	_______	_____	_____	______
De-aeration and filteration	Xanthate solution	Removing air bubbles from solution, filtering any foreign particularities	Viscose solution ready for spinning	______	_____	_____	______

Table 10 (cont.) Manufacturing of Viscose

Process	Input materials	Function	Product	Air emissions	Effluents	Solid wastes	Work environment
Spinning	- Spinning solution - Sulpheric acid - Sodium sulphate , zinc sulphate	Forcing Viscose solution through spinnerett	Viscose filaments	Sulpheric acid vapour	_____	Filament scrap	Acid vapour, noise
Scouring and finishing (for filament yarn)	Cake of filament yarn, sodium sulphide	Scouring and washing from salts and acid	Finished cakes of filament yarn	Water and acid vapour	Wastewater with salts and acid	yarn scrap	Spills of wastewater, noise
Scouring and finishing, and crimping (for filament tows)	Collected filament tows, sodium sulphide	Scouring, washing, and crimping	Scoured, finished, and crimped tows	Water and acid vapour	Waste water with salts and acid	____	Spills of wastewater, noise
Cutting and pressing into bales	Collected finished filament tows	Cutting filaments into staple fibres cotton – type or wool – type	Bales of staple fibres cotton or wool type	Particulates	____	Fibres	Particulates, noise

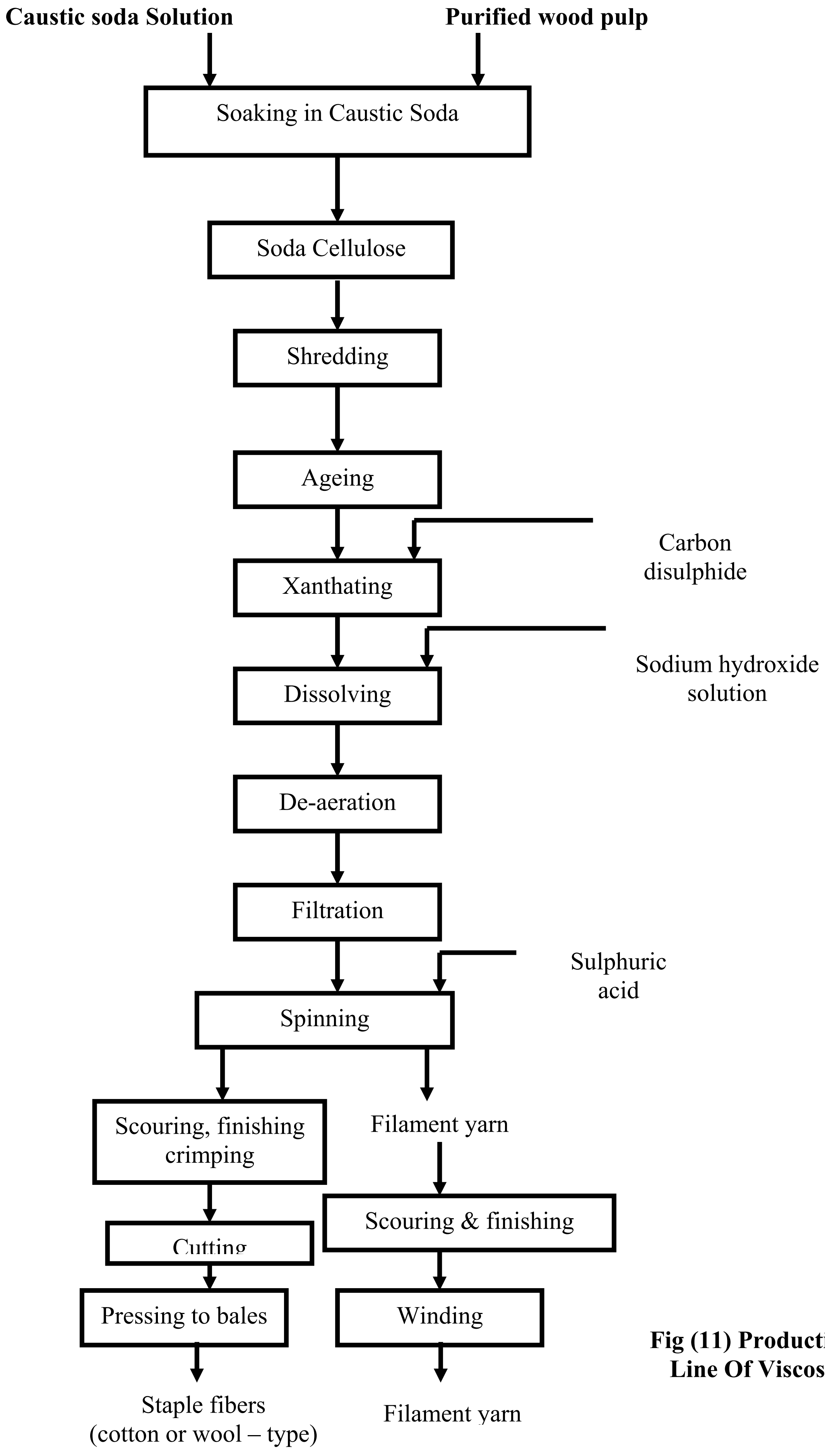


Fig (11) Production Line Of Viscose

a) Nylon Production

Table (11) gives the processes, the raw materials and products from the processes and the related pollution outputs.

Figure (12) shows the production processes for manufacturing nylon fibers and nylon yarns, as explained in the following:

Polycondensation	This is a chemical process to produce the nylon polymer using caprolactum and acetic acid.
Chipping	The nylon rope produced from the polymerization process is cut into chips.
Melting	In this stage nylon chips are melted to reach the viscosity suitable for pumping to the spinning process.
Spinning	In this process, molten nylon is pumped to spinnerettes, and the polymer streams coming out are cooled by blown air that let the polymer solidifies and form continuous nylon filament.
Drawing and twisting	The nylon yarn produced in the previous process is subjected to stretch, is given twist and is wound on a bobbin .
Texturing	This process subjects the filament yarn to heating, then inducing crimp in the filament and then cooling the filament, thus forming a textured nylon yarn.
Drawing and crimping	This process ***(for fibre production)*** is in the production line of nylon fiber in which filament tows from spinnerettes are collected to form a sheet which is subjected to stretch and crimping to give the required degree of crimp and fineness.
Cutting and pressing	In this process the collected tows of nylon filaments pass through a cutting machine which cuts the filaments into fibers with length similar to wool fibers. The resulting nylon fibers are pressed into bales with polyethylene cover

Table (11) Manufacturing of Nylon

Process	Intput materials	Function	Product	Air emissions	Effluents	Solid wastes	Work environment
Polycondensation	Caprolactum, acetic acid	Forming the polymer	Nylon polymer rope	Acid vapour	Wastewater for cooling nylon polymer, acetic acid	_____	Acid vapour, heat
Chipping	Nylon polymer rope	Cutting polymer rope into chips	Nylon chips (or pellets)	_____	_____	Nylon chips	Noise
Melting	Nylon chips	Heating up chips to melt	Molten Nylon	_____	_____	Nylon chips residual monomers	Heat
Spinning	Molten nylon	Pumping polymer into spinnerette	Nylon filaments on spools	Nitrogen, volatilised additives, organic finishes	Water contaminated with additives, other organic	Filaments, residual finishes, empty containers	Nitrogen, heat, noise
Drawing and twisting for yarn production	Nylon filament	Drawing filaments, twisting to yarn	Filament yarn	_____	_____	Yarn scrap	Yarn scrap, noise
Texturing	Filament yarn	Changing from silky yarn to textured yarn	Textured filament yarn	_____	_____	Yarn scrap	Noise
Drawing and crimping	Collected filament tows	Adjusting filament fineness, and crimping	Drawn and crimped filament tows	_____	Wastewater with chemicals	_____	Noise
Cutting	Collected filament tows	Cutting filaments into staple fibres	Nylon staple fibres (wool- type)	_____	_____	Fibres	Noise
Pressing into bales	- Bulk of staple fibres - Polyethylene sheets -Polypropylene strips	Packaging fibres in bales	Bales of nylon fibres (wool – type)	Particulates	_____	Fibres	Particulates, noise

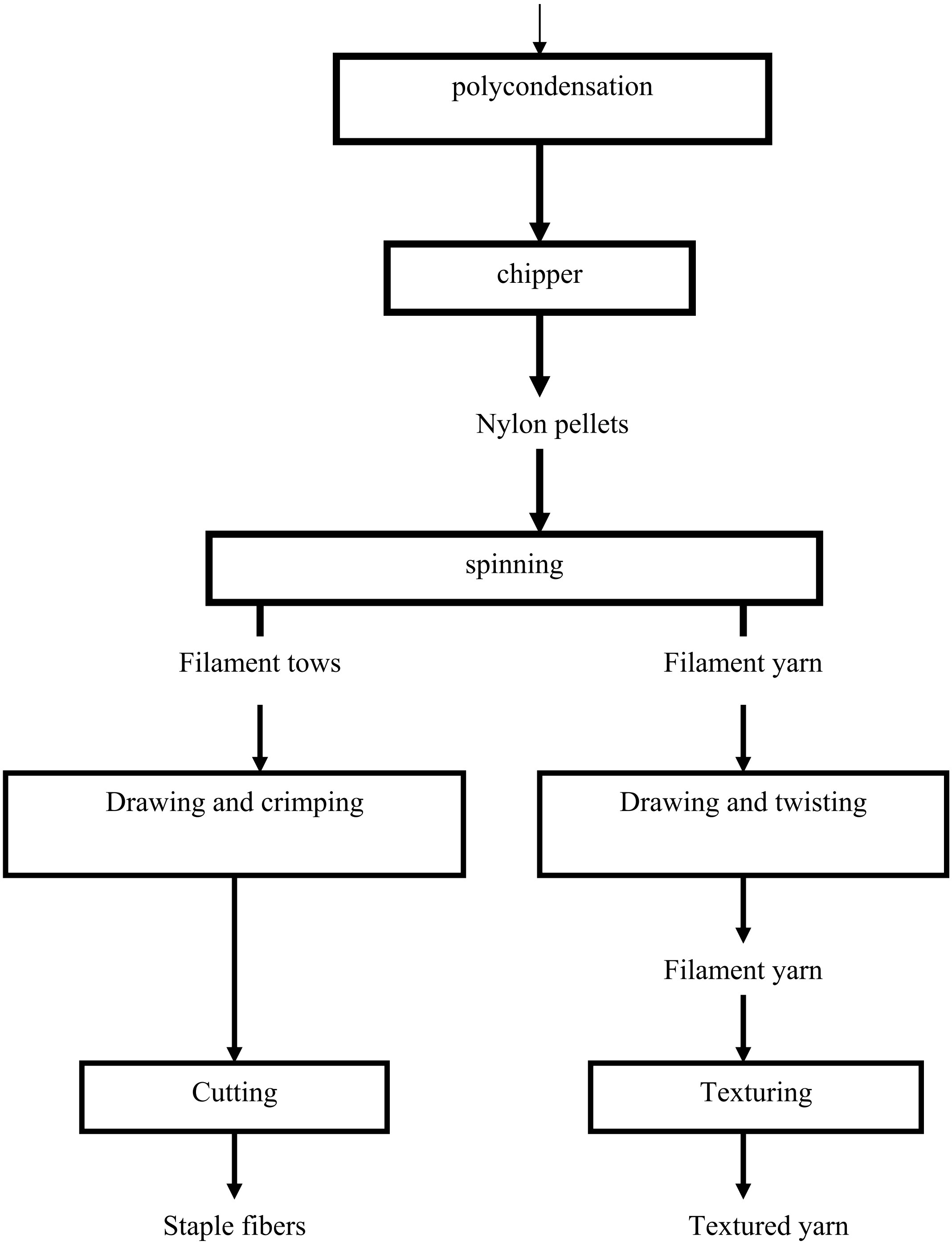


Fig (12) Production Line Of Nylon

b) Polyester Production

Table (12) gives the processes, the raw materials and products from the processes and the related pollution outputs.

Figure (13) shows the production processes for manufacturing polyester fibers and yarns, as explained in the following:

Production of ester building unit	In this process a chemical reaction is carried out between monoethylene glycol and dimethyl terephthalate to produce diglycol terephthalate.
Polymerization	In this process ***(for fiber production)*** polymerization occurs to diglycol terephtalate to produce polyester polymer.
Spinning	In this process, molten polyester polymer is pumped to the spinnerettes and the filaments come out to meet a stream of cold air and get solidified. The resulting filament tows collected in cans feed the next stage. The fineness of the resulting filaments depend on the size of the spinneret holes.
Tensioning and crimping	In this operation, the large number of tows are fed as a layer to a stage of tensioning and crimping, to adjust the fiber fineness and crimp.
Cutting and pressing	The filament sheet is introduced in this stage to a cutting machine which transforms the polyester filaments to fibers with length similar to cotton length or similar to wool length. The resulting fibers are pressed into bales and covered with polyethylene sheets.
Spinning	In this process ***(for filament yarn)*** the number of filaments coming out of the spinneret is much less than in the case of fiber production. The produced yarn in this process is known as “poy” yarn which needs further processing to produce the required yarn
Ring-twisting	In this stage poy yarn is drawn, twisted and wound to produce polyester filament yarn.
Texturing	In this process the polyester “poy” (preoriented yarn) is passed in a texturing machine which induce crimp in the filaments, resulting polyester textured yarn.

Table (12) Manufacturing polyester

Process	Intput materials	Function	Product	Air emissions	Effluents	Solid wastes	Work environment
Production of ester building unit	- Monorthylene glycol - Dimethyl terephthalate	Reacting the exchange of ester	Diglycol terephthalate	_____	Methanol Glycol	_____	Heat
Polymerization	- Diglycol terephthalate	Forming the polymer	Polyester polymer	- Methanol vapour - Glycol vapour	_____	Waste polymer	Radiation of Cs,or Co volatile monomers
Spinning (for producing tow)	- Molten Polyester polymer	Pumping polymer through spinnerette	Polyester filament tow	Volatile finishes other organics	Wastewater with oils additives, finishes organics	Filament waste chemicals, oil residues	VOCs, noise
Tensioning and crimping	- Collected filament tow - Finishing oils	Adjusting filament denier, and crimping the filaments	Drawn and crimped Collected filament tow	Volatilised finishes	Wastewater with finishing chemicals	Filament waste	VOCs, noise
Cutting	- Finished collected tows	Cutting filaments into staple fibres	staple fibres (cotton typeor wool – type)	Particulates	____	Fibre waste	Particulates, noise
Pressing into bales	- Bullk of staple fibres - Polyethylene sheets - Polypropylene strips	Pressing polyester fibes into bales	Bales of polyester fibres (cotton – type, or wool – type)	Particulates	_____	Fibre and ethylene Wastes	Particulates, packaging waste
Spinning (polyester filament yarn)	- Molten polyester polymer	Pumping molten polymer through spinnerette	Preoriented filament yarn (POY)	Vapour of finishing oil	Wastewater and finishing oils	Yarn scrap	VOCs, noise
Ring – twisting	- POY filament yarn	Drawing andtwisting filament yarn	Polyester filament yarn	_____	_____	Yarn scrap	Noise
Texturing	- POY yarn	Crimping the filaments in the yarn	Textured yarn	_____	_____	Yarn scrap	Noise

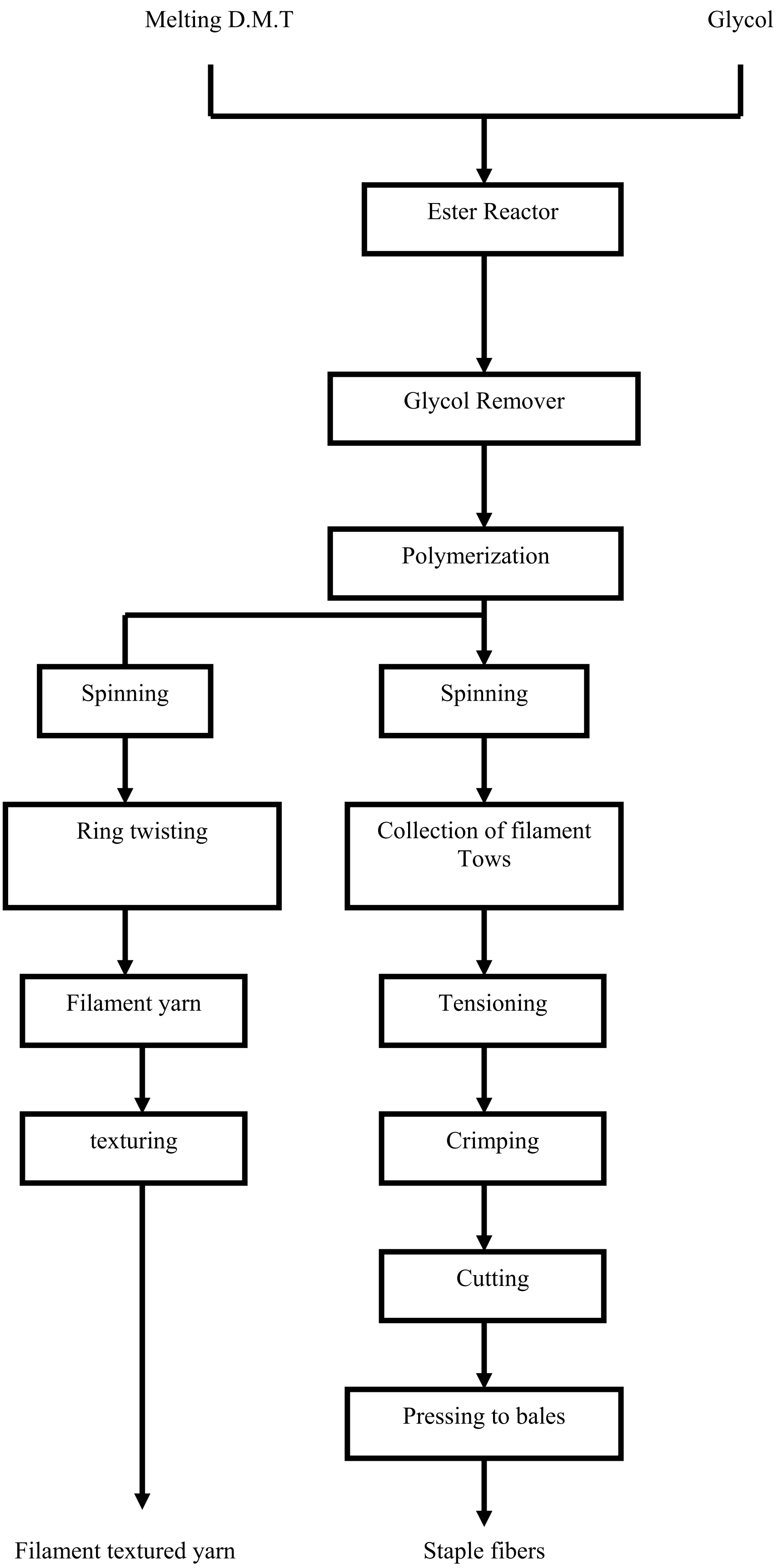


Fig (13) Production Line Of Polyester

2.3 Service Units: Description and Potential Pollution Sources.

Medium and large size facilities will have some or all of the following service and auxiliary units. Very small garment manufacturing facilities may not have any of these service units. These units can represent sources of pollution and should be inspected and monitored accordingly.

2.3.1 Boilers

Boilers are used to produce steam for:

- heat supply to the processes (scouring, sizing, dyeing, drying, ..etc.)
- electric power generation (in some large plants)

Fuel is burned in boilers to convert water to high pressure steam, which is used to drive the turbine to generate electricity. Steam can also be developed at lower pressures for the industrial processes. The gaseous emissions, due to boilers burning fuel oil (Mazot) or diesel oil (solar), contain primarily particulates (including heavy metals if they are present in significant concentrations in the fuel), sulfur and nitrogen oxides (SOx and Nox) and volatile organic compounds (VOCs)

The concentration of these pollutants in the exhaust gases depends on firing configurration (nozzle design, chimney height), operating practices and fuel composition.

Wastewater is generated due to the blowdown purged from boilers to keep the concentration of dissolved salts at a level that prevents salt precipitation and consequently scale formation. The blowdown 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. The steam condensate from the production processes, may return to the boiler (closed circuit) or discharged as wastewater causing pollution source to effluents.

2.3.2 Water Treatment Units

There are different treatment processes, depending on the water source and the application in the industry.

i) ***Water softening for medium hardness water :*** calcium and magnesium ions are removed from hard water by cation exchange for sodium ions. When the exchange resin has removed the ions to the limits of its capacity, it is regenerated to the sodium form with a salt solution (sodium chloride) in the pH range of 6-8. This is performed by taking the softener out of service, backwashing with the salt solution, rinsing to eliminate excess salt, then returning it to service. The treated water has a hardness level of less than 1 ppm expressed as calcium carbonate.

ii) ***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. The lime process reduces dissolved solids by precipitating calcium carbonate and magnesium hydroxide from the water. It can reduce calcium hardness to 35 ppm if proper opportunity is given for precipitation. A coagulant such as aluminum sulfate (alum) or ferric sulfate is added to aid magnesium hydroxide precipitation. Calcium hypochlorite is added in some cases. Currently the use of organic polyelectrolytes is replacing many of the trorditional inorganic coagulant aid. Sludge precipitates and is 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. A micro filter can then be used to remove remaining traces. A successful method to accelerate precipitation is contacting previously precipitated sludge with the raw water and chemicals. The sludge particles act as seeds for further precipitation. The result is a more rapid and more complete reaction with larger and more easily settled particles.

iii) ***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 Cooling Towers

Cooling water is used in some textile processes especially man-made fibers, such as in the production of viscose during mixing soda cellulose with carbon disulphide and the chemical reaction creates large amount of heat in the mixer which should be cooled by water. Cooling towers provide the means for recycling water and thus minimizing its consumption. The cooling effect is performed through partial evaporation. This causes an increase in the concentration of dissolved salts which is controlled by purifying some water (blowdown). The blowdown will be high in TDS and will represent a source of pollution to the wastewater to which it is discharged.

2.3.4 Laboratories

Laboratories are responsible for:

- Testing raw materials (fibers, yarn, fabrics), chemicals (dyes, detergents, …etc.), water, wastewater, …etc. to check compliance with required standards
- Quality control of product during processing and of the final product to check agreement with standard specifications
- The textile industry involves many tests dealing with chemicals that may be hazardous and need proper handling and precautions when dealing with these chemicals.

2.3.5 Workshops and Garage

Large textile facilities have electrical and mechanical workshops for maintenance and repairs of machines. Environmental violation could be due to:

- Noise
- Rinse water contaminated with lube oil

Pollution in the garage 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 system or selling it to recycling stations.

2.3.6 Storage Facilities

The specifications for the storage facilities depend on the nature and properties of the stored material

- Textile raw materials are fibrous, which are flammable and should be stored under fire precautions. If cotton bales are stored outdoor of the facility, they should be covered with fire resistant tarpaulins.
- The textile wet processes use a large number of chemicals, many of them are hazardous and require special storage, handling and management procedures as required by law.
- Powder dye storage should be equipped with a ventilation system to draw air polluted with powder dye away from the breathing zone of the worker preparing a dye dose from dye container. Powder dye is recommended to be stored in small containers so that the worker can avoid putting his face into large containers to take the required dose and exposing his breath to hazardous air emissions.
- The storage of the finished products should also be equipped with fire precautions, because yarns fabrics and garments are flammable fibrous materials. When storing resin-coated fabrics, they should be packaged to avoid the release of formaldehyde and the storage should be ventilated.
- In the production of polyester, methanol is obtained as a by-product, and as it is flammable, it should be stored in a separate storage with fire precautions.
- Fuel used for boilers, cars and trucks should be stored in underground or over ground tanks but at locations away from the textile processes or the material and product stores, and they should be equipped with fire precaution system.

2.3.7 Wastewater Treatment Plants (WWTP)

The textile industry has many wet processes which consume large quantities of chemicals and result in large amounts of polluted wastewater. This wastewater needs to be treated before being discharged to surface water, or to the public sewer. The wastewater treatment unit can remove the suspended matter, the heavy metals, …etc. so that the specifications of the treated wastewater are in compliance with the regulations of the law. In the textile wet processes, the condition of the process is steady, in a continuous manner, and there is no peaks of pollution except in rare situations. This helps to control and inspect wastewater and to treat it properly.

The potential pollution sources from WWTP are:

- Metal bearing sludge, which could represent a hazardous waste problem. Proper disposal management is required.
- Treated water could represent a water pollution problem if not complying with relevant environmental laws.

2.3.8 Cotton Dust Scavenging Unit

The major source of pollution in the textile dry processes, such as spinning, weaving, knitting, ..etc., is the cotton dust and fiber particulates. In case of high speed machines, the concentration of this pollution increases. So, scavenging systems are necessary to withdraw the polluted air from the working environment and collect it in filters enclosed in a special room. When this system is out of order, the concentration of cotton dust and fuzz may exceed the limit allowed by law.

2.3.9 Restaurants, Washrooms and Housing Complex

These facilities if exist will generate domestic wastewater as well as domestic solid waste that needs scheduled disposal.

2.4 Emissions, Effluents and Solid Waste

The previous tables (2 to12) summarize the major pollutants in the textile industry processes.

2.4.1 Air emissions

Although the textile industry is a relatively minor source of air pollution as compared with other industries, it emits a wide variety of air pollutants, especially from the wet processes, such as resin coating, printing, dyeing, ..etc, and from the dry processes such as cotton dust and fiber particulates. The textile mills usually generate nitrogen and sulphur oxides from boilers. This wide range of pollution makes sampling, analysis treatment, and prevention more complex.

The main sources of air emissions in the textile industry are:

- Cotton dust and fiber particulates are generated in the dry processes, such as cotton spinning, weaving, knitting, ..etc. Cotton dust contains bacteria, fungi, pesticides, soil, vegetable matter, ..etc.
- Volatile organic compounds (VOCs) from solvents used in scouring, methanol from PVA used in sizing, formaldehyde emitted from resin coated fabrics, glycol ethers used in desiring, and ethylene glycol, urea, kerosene emitted in printing.
- Nitrogen oxides, sulphur oxide and carbon monoxide resulting from sizing of natural cellulose fabrics
- Chlorine, chlorine dioxide, resulting from the bleaching process
- Oil and acid fumes, emitted from carbonizing process used in wool yarn manufacturing as sulphuric acid fumes. Formic acid fumes from finishing wool fabrics.
- Hydrocarbons and ammonia emitted from the printing process.
- Formaldehyde emitted from resin finishing of fabrics, and is also released from bulk resin storage tanks, finished fabric warehouses, dryers and curing ovens.

- Methanol vapor from the polymerization process in the manufacturing of polyester fiber, and it may also be emitted from finishing operations where methanol-iterated formaldehyde resins are used.
- Toluene may be emitted when used in solvent coating operations.
- Xylenes are emitted when used in printing operations.
- Ammonia is emitted when used in printing, preparation and dyeing processes.
- Methyl ethyl ketone may be used in solvent coating operations for fabrics, and causes polluting emissions.

2.4.2 Effluents

The textile industry uses high volumes of water throughout the wet processes, for sizing, scouring, bleaching, dyeing and washing of finishing products. This will result in large volumes of wastewater loaded with a wide variety of chemicals used throughout processing, and represents a major source of pollution if not properly treated before discharge to the environment.

The main sources of effluent pollution are:

- Hazardous organic materials, such as pentachlorophenol (PCP), which is anti-mildew preservative agent, used in size recipe and is removed from the fabric during scouring and finishing operations and discharged into the wastewater.
- Biological Oxygen Demand (BOD), due to the size substances removed in the desizing process, which often contributes to 50% of the BOD load in wastewater from wet processing
- Chemical Oxygen Demand (COD), due to dye bath chemicals which contribute 25-35% of COD in the wastewater
- Residual dyes and auxiliary chemicals in spent dye bath and wastewater.
- Salts, used in direct and fiber reactive dyes on cotton can produce wastewater with salt level well above the regulatory limits.
- Heavy metals, such as copper, cadmium, chromium, nickel, and zinc may be found in textile mill effluents, caused by fiber, incoming water, dyes, plumbing, and chemical impurities. Dyes may contain metals such as zinc, nickel, chromium, and cobalt. These metals are functional in some dyes, and as oxidizing agent for sulphur dyes. In dye house effluent, heavy metals arise as a consequence of heavy metal salts used in dying.
- Natural and synthetic polymers are generated in wastewater of the finishing processes, together with a range of other potentially toxic substances.
- Suspended fibers, grease, suspended material, resulting from the scouring processes.
- Color remainder from dyeing and printing processes is a source of pollution in the effluents, because in typical dyeing and printing processes, 50-90% of color is fixed on the fiber, while the remainder is

discarded in the form of spent dye baths or in wastewater from subsequent textile-washing operations.

- High temperature in effluents due to desizing, scouring, washing, …etc.
- High pH in the effluents resulting from scouring and mercerization, due to the use of alkalis and surfactants
- Toxic metals and chemicals in effluents resulting from dyeing processes of both cotton and wool fabrics, and printing and finishing of cotton fabrics.

2.4.3 Solid Wastes

The primary residual wastes generated from the textile industry are non-hazardous, such as fiber flocks, scraps of fabric and yarn, off-specification yarn and fabric and packaging waste.

Wastes associated with the storage and production of yarns and textiles, such as dye and chemical storage drums, cardboard reels for storing fabric and cones used to hold yarns for dyeing.

Cutting room waste in garment industry, generated at high volume of fabric scraps, and flock waste, resulting from shearing process of tufted carpets.

Cotton dust, trash, fiber particulates, resulting from opening and carding processes, and withdrawn by air suction from machines to bag filters.

Dirt, wool fibers, vegetable matter, grease and waxes, resulting from wool scouring.

Fiber, wasted sludge and relined sludge, resulting from wastewater treatment plant.

2.4.4 Noise Pollution

The textile industry uses a wide variety of machines, running at high speeds and causing high level of noise which may violate the limit allowed by law (90 decibel). The dry textile processes causing noise pollution are such as preparation for spinning, ring-spinning, winding, weaving, sewing, ..etc. Modern machines run at very high speeds and are expected to violate the environmental laws for noise. The textile wet processes, although they generate less level of noise relative to the dry processes, but they still cause noise pollution

2.5. Characteristics of the textile industry

The following aspects should be taken into consideration when inspecting and monitoring the textile industry:

- The majority of the textile production lines work in a continuous steady style (3 shifts per day), producing standardized product. The inspection of any pollution source could be at any time during the shift.
- Most efforts should be directed to the wet processes as these are the major contributors to pollution of the environment.
- In dyeing and finishing processes, shock polluting loads occur in wastewater when changing the color or changing the type of finish

- Small garment facilities are not worthy of environmental inspection, as they do not deal with any wet processes or chemicals.
- In case of vertical type facilities, having both dry and wet processing lines, the wet processing line should be given the priority for the environmental inspection.

3. ENVIRONMENTAL AND HEALTH IMPACTS OF POLLUTANTS

There are three main polluting sources affecting health in the textile industry, namely; cotton dust and fiber lint from the dry processes, chemical fumes and gases from the wet processes, and particulate matters and sulfur oxides, nitrogen oxides and carbon dioxide from combustion of fuel in boilers.

3.1 Impact of air emissions

Cotton dust	The first symptoms of disease are difficulty in breathing. If exposure exceeds the legal limit, workers may develop byssionsis, also known as “brown lung” disease. At advanced stages damage is permanent and disabling. Exposure to cotton dust also leads to increased risk of chronic bronchitis and emphysema.
Formaldehyde	Formaldehyde kills tissues and depresses cell functions. It causes intense irritation of eyes and nose and headaches. Formaldehyde may also cause carcinogenic effects.
Methanol	Methanol is toxic at high levels, causing damage to central nervous system and may cause blindness. Methanol is highly flammable, causing risk of fire. In the body, methanol is converted into formaldehyde and formic acid.
Detergents (surfactants)	Detergents may cause bloating diarrhea. They are irritant to eyes and skin. Cationic detergents are significantly more toxic and irritating than other detergents.
Acid fumes	Fumes of sulfuric acid cause irritation of the eyes, nose and throat (in desizing)
Sodium hypochlorite	This bleach is limited or banned in may countries. It can break down to form absorbable organo-halogen compounds, which are both toxic and carcinogenic. Hypochlorite also causes severe irritation, skin and mucous membrane damage. Chlorine gas released from hypochlorite causes severe irritation of respiratory tract and eyes
Toluene	Inhalation or ingestion of toluene can cause headaches, confusion, weakness and memory loss. Toluene may also affect the way the kidneys and liver function.
Xylene	High levels of xylenes can cause irritation of the skin, eyes, nose and throat, difficulty in breathing, impaired lung function, impaired memory and possible changes in the liver and kidneys. Both short and long term exposure to high concentrations can cause headaches, dizziness, confusion and lack of muscle coordination.

Acetic acid	Exposure to acetic acid gas can cause intense irritation of the eyes, nose and throat, and can cause skin damage.
Ammonia	Ammonia vapor is severe irritant to eyes. 100ppm causes irritation, vomiting, diarrhea, sweating and coughing. High concentrations can cause respiratory arrest.
Methyl Ethyl Ketone	Breathing moderate amounts of (MEK)for short periods of time can cause adverse effects on the nervous system ranging from headaches, dizziness, nausea and numbness in the fingers and toes, to unconsciousness. Its vapor is irritating to the skin, eyes, nose and throat, and can damage the eyes. Repeated exposure to moderate or high amounts may cause liver and kidney defects.
Carbon disulphide	Inhalation of 100-1000ppm can cause fatigue, vomiting, headaches and constipation
kerosene	Kerosene fumes cause nausea, vomiting, coughing, leading to respiratory paralysis.
Aniline black dyestuffs	These dyestuffs contain potassium dichromate which can cause dermatitis and ulceration. It has also carcinogenic effects.
Chlorinated aromatics	These have carcinogenic effects
Carbon monoxide	Reduces blood oxygen-carrying capacity, causing dizziness, weakness, headache. Concentrations above 1000ppm can be fatal within one hour
Particulate matters	Particulates smaller than 10 micron cause health damage. These particles penetrate most deeply into the lungs, causing asthma attack, cough, and bronchitis. Particulates include ash, soot and carbon compounds
Sulphur Oxides	Sulphur Oxides cause a major environmental problem due to air pollution. This compound is harmful to plant animal life, as well as many building materials. Also sulfur oxides dissolve in rain droplets, forming acidic solutions that can be very damaging when distributed in the form of rain. Acid rain is corrosive to metals, limestone, and other materials
Nitrogen Oxides	Nitrogen oxides also dissolve in atmospheric water droplets to from acid rain.
Water Vapor (Humidity)	High humidity in workplace affects the respiratory system especially for people suffering from asthma, and it is regulated by law 4/1994.
Freon	Freon is a trade name for Chloro-Fluoro-carbons (CFC_s), which are considered to be Ozone Destroying Substances (ODS_s).

3.2. Impact of effluents

The textile industry produces large amounts of polluted wastewater resulting from the wet processes, at the rate of about 200 liter per Kg product. These polluted effluents can cause damage to the environment if discharged into agriculture canals and drains as well as the Nile river for their detrimental effect on agriculture (decree 8/1993), and aquatic life, beside exposing downstream water users to possible toxic effects. The wastewater resulting from the textile wet processes contains suspended solids, fibers, solvents, metals, urea, foam, BOD, COD, toxic materials, ..etc. This type of pollution must need treatment of wastewater to achieve the legal limits and can be discharged either to public sewer or to aquatic bodies. Discharge of polluted wastewater high in BOD into lakes and sea can cause eutrification 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.

3.3. Impact of solid wastes

The textile industry produces large quantities of waste represented in trash and dust, fiber waste, yarn and fabric scraps, sludge, dye and chemical containers, yarn and fabric packaging containers. Unless these wastes are disposed regularly by suitable means, the ambient environment of the facility is polluted and violated. Sludge, resulting from wastewater treatment plant, containing hazardous compounds can subject workers to health problems during handling sludge for disposal.

3.4. Impact of noise

The textile industry is characterized by using large numbers of mechanical machines running at high revolution speeds (up to 100,000 r.p.m), especially those used in the dry processes (cotton cleaning, carding, spinning, winding, weaving, …etc). The level of noise in the work environment is expected to violate the legal limit in some of these noisy areas.

The exposure of workers to noise levels higher than 9o decibel in the workplace can cause hearing troubles. Accordingly the noise level should be inspected and monitored, especially when installing new high speed machines, or when new maintenance management is applied.

Table (14) Limits of Air Pollutants Relevant to the Textile Industry (law 4/1994)

Pollutant	Relevant processes	Threshold Limits			
		Mean time		Limits of exposure for a short period	
		P.PM	mg/M^3	P.P.M	mg/M^3
Cotton dust and fluff	Spinning, weaving knitting, ..etc.		0.2		0.6
Sulfuric acid	Desizing, viscose spinning, dyeing carbonizing				
Sodium hydroxide	Scouring, mercerizing wastewater treatment		2		
Chlorine	Blenching	1	3	3	9
Aniline	Dyeing	2	10	5	20
Ammonia	Dyeing	25	18	35	27
Ethylene	Dyeing		10		20
Urea	Printing				
Formaldehyde	Printing, finishing	2	3		
Acetic acid	Printing	10	25	15	37
Xylene	Printing	100	435	150	655
Acrylonitrile	Finishing	2			
Silicon	Finishing			20	
Yellow phosphorus	Finishing		0.1		0.3
Toluene	Finishing	100	375	150	560
Paraffin wax	Finishing		2		6
Manganese smokes	Workshop				
Carbon monoxide	Boilers	50	55	400	440
Carbon dioxide	Boilers				
Carbon dioxide	Boilers				
Nitrogen dioxide	Boilers, sizing	3	6	5	10
Sulphur dioxide	Boilers	2	5	5	10
Soldering smoke			5		
Ozone	Toluene solvent coating	0.1	0.2	0.3	0.6

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 (15) 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.

Table 15. Egyptian Environmental Legal Requirements For Industrial Wastewater

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

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 guideline 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.
- 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
- In air conditioning systems: Freon leaks are regulated by article 43 of law 4/1994, article 45 of the executive regulations and annex 8
- Near heavy machinery: noise is regulated by article 42 of law 4/1994, article 44 of the executive regulations and table 1, annex7
- 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

4.5 Concerning hazardous material and waste

Law 4/1994 introduced the control of hazardous materials and waste. The textile industry uses a wide range of chemicals in the wet processes, many of them are hazardous. These chemicals and the fuel for the boilers, fall under the provisions of law 4/1994. Articles 29 and 33 of the law make 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, such as sludge resulting from wastewater treatment of the textile wet processes effluents. 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

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5. POLLUTION ABATEMENT MEASURES

This section is concerned with pollution abatement (preventions) in the three media, air, water and soil. Three types of interventions will be considered:

- In-plant modifications, which are changes that are performed in the plant to reduce pollutant concentrations in streams through recovery of materials, segregation and/ or integration of streams, reducing the flow rate of the wastewater streams that need further treatment to reduce the hold-up of the required WWTP. This type of intervention is recommended for the textile wet processing line for finishing the fabrics, as it is the major source of pollution in the textile industry.
- In-process modifications, which are changes performed on the process such as the introduction of newer technology, substitution of hazardous dyes and chemicals with more safe alternatives, performing process optimization and control
- End-of-pipe (EoP) measures, which involve treatment of the pollutant or its separation for further disposal. Whereas in-plant and in-process modifications usually have an economic return on investment, end-of-pipe measures will be performed for the sole purpose of compliance with the laws without economic target.

Egyptian Environmental Laws do not require water and energy conservation measures. These measures have been considered in this report since resource depletion and hence conservation is a worldwide-recognized environmental issue that could be implemented in Egypt in the near future, especially in the textile industry where huge quantities of water are used in the wet processes. Water conservation measures can lead to higher concentrations of pollutants in the effluent streams. Both energy and water conservation measures will contribute to both financial and economic benefits. Table (16) gives an overview of pollution prevention techniques and their relative ease of implementation

The term Cleaner Production (CP) refers to the same concepts of pollution reduction through in-process, in-plant and resource conservation, in contradistinction to end-of-pipe treatment. In many cases, the adoption of CP can eliminate the need for (EoP) treatment.
The textile industry sector has a great potential for implementation of cleaner technology measures in the wet processes, such as sizing, desizing, bleaching, dyeing, finishing, ..etc., in which pollution abatement has been achieved with great success. New chemicals and dye stuffs are now used instead of the hazardous dyes, also law dye bath ratio is used thus reducing or preventing the pollution in wastewater.
The following (CP) and (EoP) measures have been identified for the textile industry.

5.1 Air pollution abatement measures

Cotton dust and fiber particulates

In cotton spinning and weaving, a scavenging system is used to collect the cotton dust, and fiber particulates in bag filters, which helps to achieve the legal concentration (0.2 mg/m^3).

Wet processes

Volatile organic chemicals (resulting from sizing, desizing and scouring), acid and alkali vapors (resulting from dyeing, printing and finishing), formaldehyde (from resin coating of fabrics). These air pollutants are removed from the work environment by a scavenging system. Hypochlorite (for bleaching) should be substituted by hydrogen peroxide. Low dye-bath ratio is a step towards cleaner production.

Boiler flue gases

The exhaust gases of boilers contain particulate matter due to ash and heavy metal content of the fuel, low combustion temperature, low excess oxygen level, high flow rate of flue gases. Sulphur dioxide is due to the sulfur content of the fuel. Nitrogen oxides are formed when maximum combustion temperature and high excess oxygen. Carbon monoxide is formed when incomplete combustion occurs at low air to fuel ratio

The following measures can be adopted to minimize air pollution from exhaust gases

- Replacing Mazout by solar or natural gas, because Mazout is high in sulfur content.
- Regulating the fuel to air ratio for an optimum excess air that ensures complete combustion of carbon monoxide to dioxide.
- Keeping the combustion temperature at a moderate value to minimize particulate matter and nitrogen oxides.

Gas leaks

Ammonia, Freon and steam leaks are minimized through maintenance and repair. Freon in air condition systems should be replaced by another non-hazardous refrigerant.

Odor control

Odor controls, such as absorbants, bio-filters on exhaust systems of the scavenging systems, should be implemented where necessary to achieve acceptable odor quality for nearby residents. Ventilation system should be used in powder dye store where dye recipe is to be prepared. In modern dye technology, automatic system is used to prepare the recipe (liquid dye or powder dye) and the dyestuff is fed directly through pipe to the process.(in case of liquid dye)

Table (16) Overview of pollution techniques

Type of P2 Technique	Technique	Process or Ancillary Activity	Ease of implementation
Process/equipment modification	Replacing traditional faucets	Receiving and preparation	Easy-Moderate
	Water shutoff during breaks	Processing and filling	Easy
	Water control units	Processing and filling	Moderate
	Installing flow meters	Processing and filling	Easy
	Exterior area water use reduction	Storage and distribution	Easy
Operational and housekeeping changes	Placing catch pans under potential overflows/leaks	Storage	Easy
	Covering outside storage area	Storage	Easy
	Inspection and preventive maintenance of potential discharge area	Storage	Easy
	Secondary containment	Storage	Easy-Moderate
	Monitor liquid fill machines	Processing and filling	Easy- moderate
	Cleaning prevention	Cleaning	Easy-Difficult
	Pre-cleaning and dry cleanup	Cleaning	Moderate
	Skim grease traps regularly	Cleaning	Easy
Recycling/ reuse	Counter current washes	Processing and filling	Moderate
	Process water reuse	Processing and filling	Easy- Moderate
	Water re-circulation units	Processing and filling	Moderate
	Water used to chill product	Processing and filling	Moderate
	Residuals management	Processing and filling, storage and distribution	Easy-Moderate
	Recycling refrigerants	Refrigeration	Moderate
	Reducing/recycling/reusing packaging	Processing and filling	Easy-Moderate
Material substitution and elimination	Laboratory inventory reduction	Laboratory	Easy
	General inventory control	Purchasing	Easy
	Using alternative refrigerants	Refrigeration	Moderate

5.2 Water pollution abatement measures

In-plant modifications

- The use of natural starch in sizing causes deizing effluents with very high organic concentrations due to the use of acid or enzymes. So the natural starch is substituted by PVA and gums which can be removed by a simple hot wash.
- In case of desizing the starch, the use of hydrogen peroxide decreases the BOD, as the starch is degraded to carbon dioxide and water.
- The use of newer enzymes which degrade the starch size to ethanol instead of anhydroglucose, then the ethanol can be recovered by distillation for use as a solvent or fuel, thus reducing the BOD load in the desized effluent considerably
- Combining the desizing and scouring processes can save water and energy
- The use of Plasma technology for fabric cleaning, using no chemicals helps to reduce the pollution in wastewater of the finishing plant.
- The use of automatic dyeing plant, where the dye and auxiliary chemicals are automatically prepared by computer with optimum recipe and fed to the dye bath through pipes. This technology is considerably reducing the pollution in the dye effluents, as the automatic dosing system distributes all the chemical and auxiliary products to the dyeing machines.
- Dilute alkali from mercerizing should be reused in scouring, bleaching or dyeing operations. Processes should be optimized so that discharges from alkaline treatment (mercerizing) can be minimized .
- The plant for dyeing should recycle dyes if possible by the standing bath technique, going from lighter to darker shades.
- The printing plant can be modified to recover the excess printing pastes, through optimized paste preparation and supplying systems, and can be recycled and reused.
- The plant for resin finished goods should be equiped with formaldehyde scavengers during application and storage of goods.

In-process Modifications

- Implementation of control system involving pressure regulators on the steam lines, temperature controller, flow controllers, …etc.
- Sizes used within the weaving mills should be degradable, recoverable, water soluble and universally applicable. Starches that have high BOD should be replaced by other less polluting sizes such as acrylates or partially substituted by PVA, which reduce the BOD load from the unit by 90%. Up to 50% of low viscosity sizes (PVA, CMC) can be recovered by using high pressure or vacuum technology in a pre-wash stage and can then be reused following sterilization (>80^{o}C)

- In case of oxidative desizing, where the starch is degraded by oxidation, the use of hydrogen peroxide is recommended as it results in much lower BOD in the effluent, that is much less polluting. In this case extreme care should be taken for temperature control, residence time and chemical concentrations.
- In scouring, no more than the optimum amounts of alkaline recipes should be prepared
- Alkalis should be recycled and reused as much as possible; rinsing water should be reused for preparing the scouring bath.
- Hydrogen peroxide should be used as the bleaching agent, preferred to chlorine containing compounds, such as hypochlorite this will take the factory one step closer to obtaining an “eco-label”
- Liquid ammonia is a low pollution substitution for conventional mercerization (sodium hydroxide)
- Heavy cotton fabrics treated with liquid ammonia require less dye for a given depth of shade, and consequently contribute to reduction of pollution.
- To reduce the pollution in the dye effluents, low dye bath ratio is used
- In sulfur black dyeing sodium sulphide is used as reducing agent, and dichromate as oxidizing agent. These two compounds are both toxic and hazardous to handle, may leave harmful residues in the finished fabric, and generate effluents that are difficult to treat and damaging to the environment and their discharge into the environment is also strictly controlled. These two chemicals can be substituted by glucose for reduction and sodium perborate for oxidation of woven fabric and hydrogen peroxide for oxidation of knitted fabrics.
- Aniline black dyes can be replaced by sulfur dyes to minimize pollution in the resulting dye effluents.
- Acetic acid should be replaced with formic acid which has a lower BOD value in the effluents.
- Full or partial substitution of gum thickening by emulsion thickening in printing.
- Replacing the use of white spirit or kerosene by water-based systems in printing
- Using biodegradable natural thickening auxiliaries or highly degradable synthetic thickeners in printing.
- Avoiding the use of solvent-based printing pastes in pigment printing, and using pigments which give improved absorption and lower effluents for reducing COD.
- Building the finishing chemicals into the fibre during spinning is preferred over applying the finish at a later stage
- Using formaldehyde-free cross-linking agents for cellulose textiles and formaldehyde-free dye-fixing agents.

- Application of fireproofing chemicals is best done using techniques which consume minimal amounts of water (e.g. vacuum, back coating, foam) or lead to minimal amounts of residues.
- In the finishing process, formaldehyde should be substituted by polycarboxylic acid to reduce the pollution in finishing effluents.
- Optimizing process chemical use is possible to reduce chemical consumption in textile wet processing by 20-40%, resulting in an estimated 30% decrease in the pollution load.

End-of-pipe treatment

The Egyptian textile industry, especially the older mills, mostly use heavily polluting wet processes such as hypochlorite bleaching, starch based materials, aniline dyeing, pigment printing using kerosene, chemicals containing heavy metals, formaldehyde or ammonia releasing agents. These polluting compounds should be removed from the wastewater by end-of-pipe treatment in a wastewater treatment plant to comply with the specifications of the environmental law before discharging to drain canals, river, or public sewer. Because of the high content of pollutants and suspended solids, fibres, COD and BOD in the wastewater of the textile wet processes, end-of-pipe treatment frequently involves settling tanks and biological treatment. Pretreatment of effluents consists of screening, flow equalization, neutralization and air flotation (to remove grease oils, wax and solids), and is normally followed by biological treatment. If space is available pond systems are potential treatment methods. Other possible biological treatment methods include trickling filters, rotating biological contactors and activated sludge treatment.

Pretreated textile effluents can be discharged to a municipal sewerage system, if capacity exists with the approval of the relevant authority.

5.3 Abatement measures for solid waste

Scrap

Fiber waste, yarn and fabric scrap are collected and sold or reprocessed and these are non-hazardous.

Dust and trash

Cotton dust and trash are collected in bag filters and are disposed regularly through a specialized organization and according to a specific schedule.

Sludge

- The treatment of wastewater resulting from the textile wet processes results in large quantities of sludge. This sludge can be hazardous to health by absorbing pathogens that multiply in this favorable medium and toxins.
- Sludge can also be generated from water treatment when lime and chemicals are used.

5.4. Abatement measures for noise

The textile industry is known to cause high levels of noise, especially the dry processes (spinning, weaving, ….etc.) because of the large numbers of high speed machines. The following are some recommendations for noise level reduction:

- The arrangement of machines should be evenly distributed over the area to avoid concentration of noise, and sufficient space between machines should exist to allow to dissipate the noise
- Implementing the periodical maintenance program especially the high speed rotating parts.
- Lubricating the rotating and moving parts of machines according to the schedule recommended by machine manufacturer.
- Monitoring the precision of mounting and setting of the rotating parts in machines to avoid vibrations causing noise
- Enclosing the mechanisms causing noise in specially designed container made of materials absorbing the noise.
- The construction features of the factory building (openings, wall material, floor, …etc.) should contribute to the reduction of noise level.

5.5 Water and energy conservation

The textile industry consumes huge quantities of water in the stage of wet processing (finishing), and the rate of water consumption may exceed 200 liters per kg of product. This shows the importance of water conservation in the manufacturing cost, and using water more efficiently can help to reduce water and sewer service costs.

The textile industry is considered high energy consuming industry because of the large number of machines included in the production line, and the heating and drying in the wet processes to finish the textile products. The energy cost represents a significant percent of the total manufacturing cost, so that energy conservation is essential to reduce the cost and to help in competition.

Water conservation

- Installing water meters to monitor water use, which should not exceed 200 liters / kg product.
- Using automatic shut-off nozzles and marking hand-operated valves in such a way that open, close and directed-flow positions are easily identified.
- Using high pressure, low volume cleaning systems, such as CIP (clean in place) for washing equipment.
- Installing liquid level controls with automatic pump stops where overflow is not likely to occur.
- Recycling cooling water through cooling towers.
- Minimizing spills on the floor minimizes floor washing in the dye house
- Repairing leaks in the water pipe network.
- Handling solid waste dry.
- Recycling steam condensate whenever possible.
- Using technologies which do not require large quantities of water, such as low dye bath ratio, high pressure steam washing

and plasma cleaning of fabrics.

Energy conservation

- Insulation of steam pipe lines
- Insulation of steam traps
- Repairing or replacing steam valves
- Maximizing boiler efficiency
- Installing pressure regulators on steam lines
- Using technologies which save energy
- Monitoring the rate of energy consumption for the factory (K.W.H/kg product) and comparing it with the international standards.
- Reducing the rate of end breaks per thousand spindle per hour on the spinning machine, because the production / hour increases while the energy consumption is constant, resulting in lower specific energy consumption.
- Optimizing the level of light intensity, and avoiding bright lighting of work area.

6.ENVIRONMENTAL SELF-MONITORING

The Self-Monitoring (SM) is a process that 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:

- Emissions monitoring, which covers releases to air, wastewater and solids and hazardous waste as well as regulated working conditions.
- Monitoring of process parameters (operation controls) that are directly related to the releases e.g. temperature, pressure and humidity. In addition, process conditions, e.g. shutdowns, maintenance operations and spills need to be 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 14) 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 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 2001). The final part of the planning stage is developing an action plan for meeting the targets; including schedule, resources, and 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 prepared plan has to be developed.
4. ***Checking and corrective actions.*** The company monitors its operations and activities to assure 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.

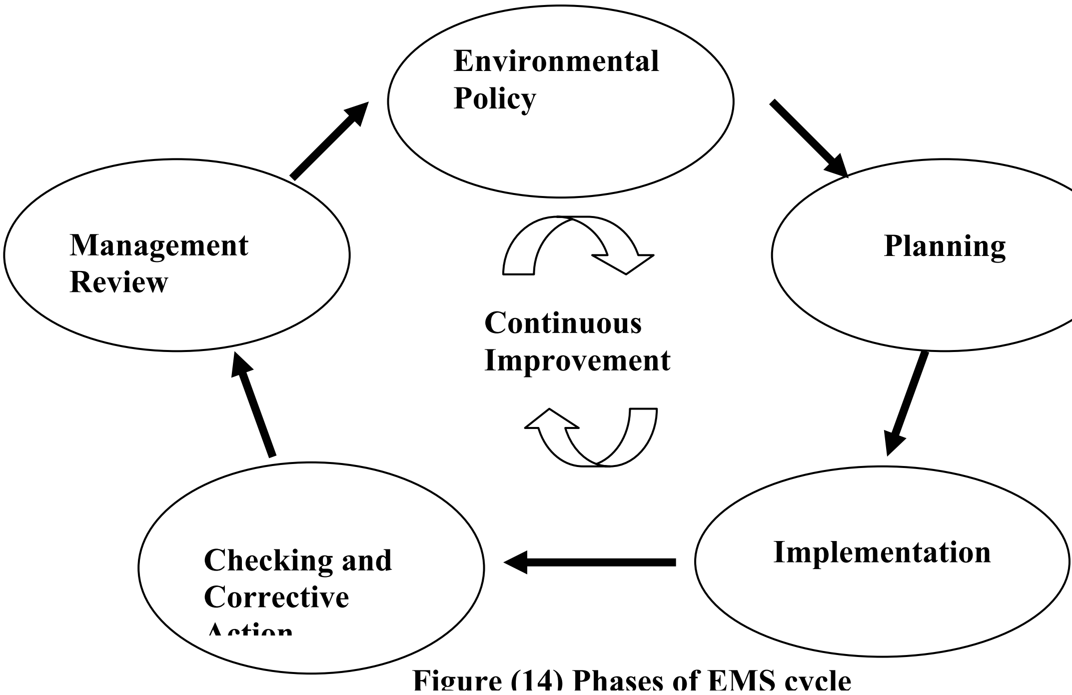


Figure (14) Phases of EMS cycle

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. Considering 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 SMS, 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 SMS means that the environmental performance of the plant is improved.

The implementation of SM results in a large amount of data that needs 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 (15) illustrates the 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.

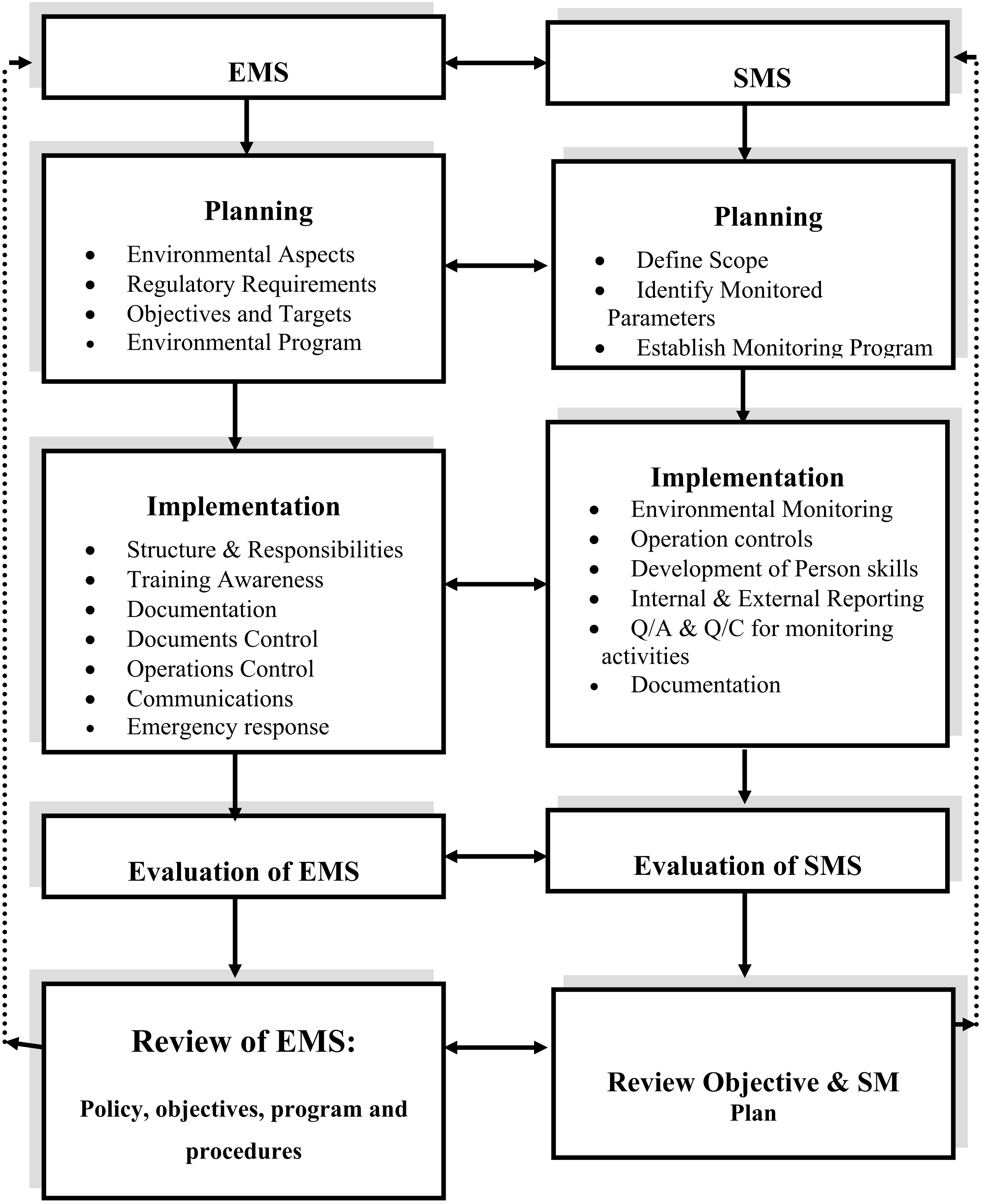


Figure (15) Relationship between EMS and SMS

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 will help both partners i.e. the operator and the competent authority in achieving their objectives in terms of reliability of emissions data and environmental performance.

7. PLANNING SELF-MONITORING

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.

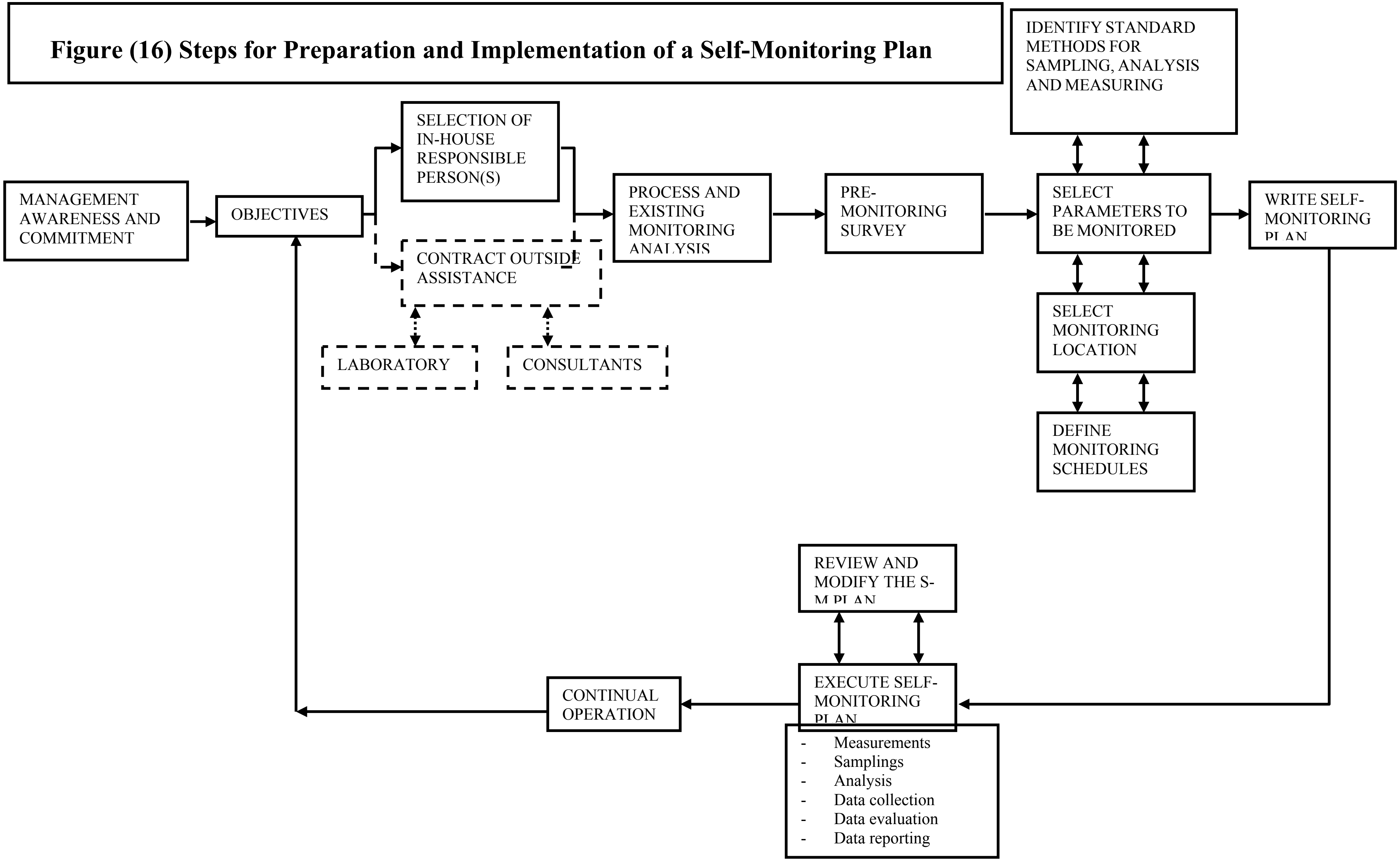
With reference to "Guidebook for Industrial Self-Monitoring", the main elements of the Self-Monitoring Plan, that describes the SMS, include:

- 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 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 a "Basic Self-Monitoring System" which comprises the minimum requirements. In these case where self –monitoring is not mandatory, the operator can build a "basic" SMS 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 an 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 constrains.

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 (16) presents the various steps for the preparation and implementation of a self-monitoring plan.

Figure (16) Steps for Preparation and Implementation of a 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 (17) presents an example of a chick-list for existing self-monitoring activities.

Table (17) Example for assessing the status of existing monitoring activity

Monitored activity	Location	Parameter	Associated Tasks	Person in charge	Time schedule
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 context of interpretation. Such information is about:

- Identification: Name, address, plant location, name of owner, manager and head of environmental department.
- Inputs names, type and amount: Raw materials, chemicals, auxiliaries, 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, analysis 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 the finishing stage of industry.
- Determine the cases 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 are 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 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 regulation). 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 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:

Normal emissions	Occur during normal operation and normal process and abatement technique conditions
Diffuse and fugitive emissions	These are emissions from a certain process but from scattered points such as emissions from ventilation ducts, barrels, scattered small storage sites. 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.
Exceptional emissions	Exceptional emissions refer to varying input or process conditions, start-ups, shut-downs, by of a process for malfunctioning and accidental causes.
	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.

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 a 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 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. The advantages and disadvantages of surrogate parameters are summarized in Table (18).

A surrogate can be used for compliance monitoring purposes if all the following conditions are met:

- It is closely and consistently related to a required direct value (e.g. fuel sulfur vs. directly measured SO_2, relationship between opacity and particulate concentration, condenser temperature and VOC emissions).
- It is regularly calibrated against the direct value.
- It is cheaper or easier to monitor than the direct value, or gives more frequent information
- Its value can be 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.

Table (18) Advantages and disadvantages of surrogate parameters

Advantages	Disadvantages
- Cost savings - More continuous information e.g. continuos opacity vs. periodic dust sampling - Allow more positions for discharge monitoring - Sometimes more accurate e.g. fuel sulfur vs. SO_2 - Give early warning of possible abnormal emissions e.g. combustion temperature warns for increase in dioxin emissions. - Cause less disruption to process operation. - May combine information from several direct measurement e.g. temperature indicates energy efficiency, emissions and process control.	- 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. - 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.

Input + Generation = Output + 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 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. In a fabric coating operation, for example, pigments in the coating resin may leave the operation as part of the product (the coating on the fabric and as residues) from the process sent for disposal.
- **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 given 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 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 calculation

Engineering calculations are assumptions and/or judgements 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 RAW MATERIALS, UTILITIES AND PRODUCTS

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 include the quantity and quality of raw materials, chemicals, fuel and water used.

8.1 Raw materials and chemicals

The amount of raw cotton or wool per day and cost / kg are important monitoring parameters. The raw material can also be yarns for a weaving or knitting factory, or can be greig fabric for a dyeing and finishing factory. The quality of raw cotton or wool is assessed by physical mechanical and chemical tests before acceptance. These tests confirm the suitability of raw material to the required level of quality. The quality of raw cotton indicates the amounts of trash and dust that may pollute the environment. Also the quality of raw wool indicates the amounts of grease, squint and suspended fibers expected to pollute wastewater of the factory. The chemicals used in the wet process indicate the types of pollutants, in air (acid fumes. VOCs, toxic gases) or in effluents (BOD, COD, heavy metals, toxic compounds, ..etc.). Table (19) shows the monitoring of raw materials and chemicals

Table (19) Monitoring of raw materials and chemicals

Parameter	Monitoring method	Indication
Amount of raw materials (cotton wool) and chemicals (starch, detergents, dye stuffs, pigment, ..etc.) necessary to produce 1 ton of product	Weighting, measuring, book keeping recording	Rationality in the use of raw materials
Quantity of material waste per unit of product. Quantity of dye stuffs, chemicals per unit of product	Weighting, measuring, book keeping and recording	Losses, process efficiency, storing or handling problems
Quality of raw material and chemicals used in production	Cotton type and grade, staple length, fineness, trash content. Quality number of wool, oil percent.	Avoiding possible production problems due to bad quality. Identifying chemicals harmful for the environment (chemical fumes, toxic gases, BOD increase if discharges to the sewer.
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 and 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, Table (20).

Table (20) Monitoring of Utilities

Parameters	Monitoring Method	Indication
Energy consumption per ton of product • 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 and its variability	Flow measurements, book keeping and recording	Water use efficiency, most of the discharge related parameters are calculated
<u>Quality of the utilities</u> Steam: Pressure level Degree of saturation	According to the specific criteria	Impact on the smooth running and efficiency of processes
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 (21).

Table (21) Monitoring of Products

Parameters	Monitoring Method	Indication
- Amount produced (ton/shift) - Final product (yarns, woven fabric, knitted fabric, finished fabric, garment, ..etc.)	Recording and book keeping	Production statistics
Defected product as a percentage of the total production (out of specifications) – level of imperfections (major defects, minor defects)	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 (22) present the major processes in each production line of the industry and the parameters that should be monitored to minimize losses, maximizing productivity and predict maintenance needs.

Table (22) Operation Control

Major pollution process	Cause of pollution	Affected media	Parameter monitored	Method used	Indication	Frequency/ Duration
Cotton spinning line						
Opening and cleaning	Cotton dust and lint – particulates	Air pollution	Cotton dust level mg $/m^3$	Vertical elutriator	Pollution of work environment	Every 6 months- when changing equipment
Spinning (ring or open-end)	Noise	Work environment	Noise level	Decibel instrument	Bad maintenance	Monthly
Wool spinning line						
Scouring (for wool pretreatment)	Solvents, Soaps, sulfuric acid	Air pollution- wastewater (high solids, BOD, COD, grease, wool impurities, detergent.	Amount of flow of effluent - Concentration of VOC_s	Gas analyzer Analysis of effluents	Air pollution odor- effluent characteristics	Once a month
Weaving line						
Slashing (sizing)	Natural starch, PVA, CMC Oils, Urea, glycol	Air pollution (methanol)- wastewater (high BOD, COD, metals)	Concentration of air pollution - pollutant concentration in effluent.	Gas analyzer - Analysis of effluents	End of pipe effluent characteristics spills of size washing residues	Once a month
Weaving	Fiber lint- Noise	Air pollution work environment	Lint concentration - Noise level	Vertical elutriator- Decibel inst.	Pollution of work env. - Noise pollution	Once a month
Finishing line (wet processes)						
Desizing	Enzymes, sulfuric acid, detergents	Air pollution wastewater (BOD, COD, metals, lubricants)	Concentration of pollutant in air and in effluents	Gas analyzer - Analysis of effluents	Chemical consumption	Once a month
Carbonizing	Sulfuric acid sodium carbonate	Air pollution (acid fumes) occasional acid bath dumps in effluents.	pH in waste water	Gas analyzer - Analysis of effluents	Excess chemical use in bath.	Once a month

Table (22) cont. Operation Control

Major pollution process	Cause of pollution	Affected media	Parameter monitored	Method used	Indication	Frequency/ Duration
Scouring	Surfactants solvents (chlorinated) Alkali	Air pollution (glycol ethers) High BOD, temp., very high pH, detergents in effluents	Concentration of pollutant in air Concentration of pollutants in effluents	Gas analyzer - Analysis of chemical Constituents in wastewater	Effluent characteristics	Once a month
Bleaching	Hypochlorite or hydrogen peroxide	Air pollution (chlorine) chemical fumes, acetic fumes high pH and temp	Gas concentration in air. pH in effluents	Gas analyzer- chemical analysis of effluents	Use of hypochlorite not recommended Effluent characteristics	Once a month
Mercerizing	Sodium hydroxide, surfactants acid	Wastewater very high pH, dissolved solids	Amount of chemicals in effluents	Chemical analysis	Effluent characteristics	Once a month
Dyeing	Benzidine based dyestuffs, amine releasing dyes, dichromate acetic acid, toxic metallic salts	Air pollution VOCs (glycol ether), ammonia -polluted effluent with dissolved solids and COD, some metals	Concentration of pollutants in air amount of pollutants in effluents- toxicity of wastewater	Gas analyzer Chemical analysis of effluents	Work environment Effluent characteristics	Once a month
Printing	Pigments, dyes, acids alkalis, thickeners, solvents, binders	Air pollution (VOCs, Urea, formaldehyde kerosene) wastewater polluted with COD, salt, solvents, ...etc.	Pollutant concentration in air and in effluents	Gas analyzer Chemical analysis	Work environment Effluent characteristics	Once a month
Finishing	Resins, softeners, silicone, kerosene, formaldehyde, asbestos, metallic salts	Air pollution with formaldehyde vapors- wastewater polluted with BOD, COD, suspended solids toxic materials	Air emissions and contents of effluents	Gas analyzer- Chemical analysis of effluents	Work environment	Once a month

Table (22) cont. Operation Control

Major pollution process	Cause of pollution	Affected media	Parameter monitored	Method used	Indication	Frequency/ Duration
For All Units of Wet processes						
Equipment and floor washing	Detergents, oil and grease	Wastewater contains hazardous materials	Amounts	Book keeping	Effluent characteristics	Once a month
Server Units						
Boiler and steam systems	Particulates CO_z, CO_2, NO_x SO_2 Hot condensate with BOD in wastewater	Air pollution and wastewater pollution	Pollutant concentration in air and wastewater	Gas analyzer chemical analysis of effluents	Work environment	Once a month
Wastewater treatment	VOC_s, vapours and mists, salts and chemicals- sludge	Air pollution Effluents containing treatment chemicals	Pollutant concentration	Gas analyzer chemical analysis	Work environment Effluent characteristics, toxicity of sludge	Once a month
Man-made Fiber production (rayon – nylon – polyester)						
Scour, dye, bleach	Oil, detergent anti-static, lubricant, chlorine or sulphate hydrochloric acid, sulphonated oils, methanol	Air pollution Effluents	Pollutant concentration	Gas analyzer Chemical analysis	Workplace environment-characteristics of effluents	Once a moth

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 which causes loss of plant profitability. The cost of unscheduled breakdown resulting in loss of production can be substantial, and the cost of repairs may 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 and are 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 that maintenance is a pollution prevention measure as it increases the efficiency of the unit, minimizes water consumption by preventing leaks, helps to conserve energy through proper maintenance of electric and mechanical equipment as well as insulation of steam pipes. Table (23) 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 and 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 (23) Monitoring of 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, effluent and solid and hazardous waste. Section 4 presents the various law and regulations that apply to emissions, effluents and wastes from the dairy industry. Expected pollutants and hazardous releases from the industry are specified in section 2.4. 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. Table (24) presents the compliance monitoring activities for the different aspects of pollution as per environmental laws.

Monitoring of pollutants and releases requires careful consideration of the techniques being used because of 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 next section.

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 exterior measurer.
Periodical emission measurements are carried out annually for the following emission components: NOx,SO2, CO,CO2, Cl and particles. In all cases, it should be noted that regular maintenance, control and calibration are needed to obtain an acceptable measurement accuracy level.

Continuous measurements: The continuous measurements describe the temporal variation of the concentrations of the emission components during the operation. General requirements for continuous monitoring systems are that the sampling locations should be representative and that the monitoring equipment should be suitable for the concentrations to be monitored in the prevailing circumstances. The emission control data system should preferably be part of the process control system. Sulfur dioxide, TRS, particles, carbon oxide are generally measured continuously.

Emission calculation: Differences between the different calculation 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 can not be recorded by emission measurements can be substantial.

10.2 Effluents (wastewater)

The regulations set the limits for the concentrations of specific pollutants in wastewater when discharged to a 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 products or as purification efficiencies. Limit values are set for a larger number of parameters such as COD/BOD_5, TSS, phosphorus and nitrogen.

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

- Wastewater flow (Q), m^3/d
- Total suspended solids (TSS), mg/l
- Temperature ,C
- Chemical oxygen demand (COD_{Cr}) Biological oxygen demand) BOD_5)
- Total nitrogen (N), mg/l
- pH
- Conductivity, mS/m

***Flow measurement*:** Measuring of the total wastewater flow is required for the operation of the wastewater treatment plant. There have been no provisions on the procedures 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 venture 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. The structure of the measurement system, a possible mounting fault or a false choice for measurement area can cause errors. Other sources of error or factors disturbing the measurement are dirt deposition and temperature variations. Evaluation of the total error is extremely difficult, as it must include all these factors.

Sampling: Well realized sampling is essential for determining of wastewater discharges. There are general instructions for wastewater sampling. However, industry-specific problems such as variation of the wastewater quality or flow rate have to be solved on case-by-case basis.

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 wastewater load peaks, quality variation and the variation range of the significant 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 flow meter.

Sampling period and sample size should be considered on case-by-case basis 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 solid 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 program may be needed for each plant. The program 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.

> It is important to mention that in year 2000, EEAA/Central Laboratories developed a document detailing all the standard sampling and analysis techniques for wastewater

Calculations : Wastewater discharges are calculated and reported as specified 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 wastewater treatment is also controlled by calculating the reduction of organic matter (BOD, 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 at the monitoring points before and after the treatment, applicable limit values and also some production information.

10.3 Monitoring of solid waste

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, long term behavior and the properties of the waste. The approval for using a landfill for a specific waste is based on the origin and the properties of the waste. The evaluation of the waste is based on the following:

- 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

Table (24a) Compliance Monitoring for Air pollution, Workplace and Wastewater

Major pollution sources	Impact	Parameter monitored	Method used	Source type		Operating		Person responsible	Frequency
				Point	Diffuse	Normal	Exceptional		
Boilers									
Flue gases	Air	Particulate matters Sulphur oxides Nitrogen oxides Carbon dioxides	Gas analyzer						Monthly
Fans	Work environment	Noise level	Decibel instrument						Monthly
Cotton spinning line									
Opening & cleaning	Work environment	Cotton dust	Elutriator						Monthly
Spinning & winding	Work environment	Noise level	Decibel inst.						Monthly
Wool spinning line									
Slashing (sizing)	Work environment Effluents	VOCs BOD, COD							Every 3 months
Weaving (looms)	Work place environment	Noise level particulates	Decibel inst. Eluttiator						Every 3 months
Finishing line (wet processes)									
Desizing	Work environment Effluents	VOCs BOD, COD, metals, biocides	Gas analyzer- chemical analysis						Every 3 months
Carbonising (wool)	Work environment. Effluents	Acid fumes acid bath dumps	Gas analyzer chemical analysis						Every 3 months
Scouring	Work environment. Effluents	VOCs BOD, pH, temp., detergents	Gas analyzer chemical analysis						Every 3 months
Bleaching	Work environment. Effluents	Chlorine fumes - acetic acid fumes- pH- temp	Gas analyzer chemical analysis						Every 3 months
Mercerizing (cotton only)	Effluents	High pH, dissolved solids	chemical analysis						Every 3 months

Table (24a) cont. Compliance Monitoring for Air pollution, Workplace and Wastewater

Major pollution sources	Impact	Parameter monitored	Method used	Source type		Operating		Person responsible	Frequency
				Point	Diffuse	Normal	Exceptional		
Dyeing	Work environment Effluents	VOCs, ammonia Dissolved – solids COD, metals.	Gas analyzer chemical analysis						Every 3 months
Printing	Work environment. Effluents	VOCs (glycol, urea, formaldehyde, kerosene) COD, salt, metals	Gas analyzer chemical analysis						Monthly
Finishing	Work environment. Effluents	Formaldehyde combustion exhausts BOD, COD, toxic solids	Gas analyzer chemical analysis						Monthly
Garment production line									
Cutting, sewing	Work environment.	Particulates VOCs Noise level	Gas analyzer chemical analysis						Every 3 months
Man-made fiber production line									
Polymerization, spinning, cutting	Work environment. Effluents	Volatilized monomers. Solvents, residues, oils	Gas analyzer chemical analysis						Monthly
Wastewater treatment plant									
Chemical treatment	Work environment. Effluents	VOCs, vapors, mist BOD, COD, pH, toxic metals, grease temp., suspended matters.	Gas analyzer chemical analysis						Every 3 months

Table (24b.) Compliance monitoring plan for solid waste

Process Unit	Type of waste	Tons/year	Tons /ton production	Internal Utilization		Discharged	Frequency
				Reused	Recovered		
Packaging	Bottles Tetra Pack						Depends on needs
Workshops	Scrap						Depends on needs
Garage	Scrap						Depends on needs
Wastewater Treatment Plant	Sludge						Depends on needs

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 Annex A. Figure (17) 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

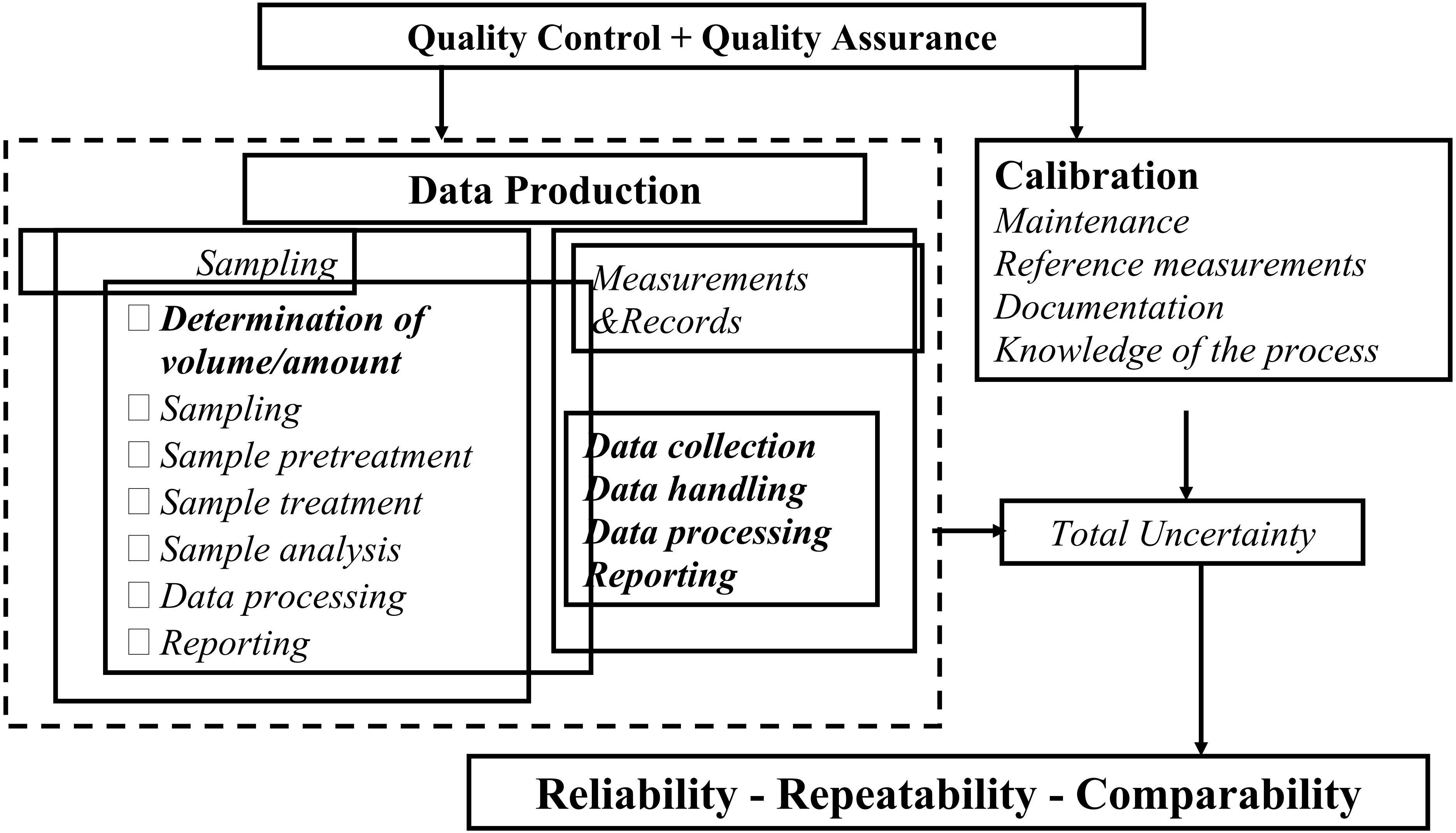
11.2.1 Techniques for summarizing and illustrating data

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 (17) 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 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

The general objective for the self-monitoring system is to produce data that is representative, repeatable, reliable, compatible and comparable. These characteristics is 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 g/t ± 2 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 / m^3, PPM, % O_2): 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.

<u>Solid Waste Loads:</u>

- 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
• 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 m3/year	Notes
• 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 m3/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
• 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 (NOx, Sox, COx, 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

- *"Monitoring and Control Practices of Emissions in Pulp and Paper Industry in Finland", 1998, Saarinen K., Jouttijarvi T. and Forsius K., Saarinen K., Finnish Environment Institute*

- *"Data Production Chain in Monitoring of Emissions", 1999, Saarinen K, Finnish Environment Institute.*

- *Draft Document "Self-Monitoring Manual for Textile Industry", August 2002, prepared by Dr. Mohamed Sultan, Faculty of Engineering, Alexandria University.*