



The Importance of Waste and Environment Management in Printing Industry

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Abstract

All kinds of materials that become useless during production activities, damage the environment and must be exterminated are generally called waste. Waste is also defined as all materials thrown away by its manufacturer or a person or entity who owns it and causes a harmful change at environment.

The most important of the solid, liquid and gaseous wastes produced in the printing industry before, during and after the printing process are waste ink, ink sludge and solvents emerging after machine washing, wastewater of water-based ink, plate and film developer and fixer solutions, waste papers, waste films, faulty prints, cleaning solvents and volatile organic compound (VOC) emissions emerging from IPA use. Some of these wastes fall into the hazardous waste category due to their processing characteristics during the production process. Effective and regular extermination of these wastes is necessary to protect the environment and employee health. This can be provided only by the application of waste management. Some wastes are recycled and reused at printing industry, but in some cases that recycling is impossible, these wastes should be eliminated without harming human health and environment. Especially the materials whose disposal is compulsory should be classified at the source and sent to licensed disposal companies.

As a new sector, waste management industry should develop new and special processes for printing technologies wastes. Owners of printing companies should be informed about waste management. At waste management process, the most appropriate clean production techniques should be used, waste production should be prevented or minimized and wastes should be recycled effectively.

The aim of this study is to provide suggestions and contributions for the possible best ways of preventing the wastes from harming the nature and disposing or recycling of the wastes generated during production in the printing industry.

Key words

Waste Management, Printing Wastes, Protecting the Environment

1. INTRODUCTION

Systems created and sustained by interrelationships between living creatures within a certain area and surrounding inanimate environments are named as “ecosystems”.

An ecosystem is consisted of four fundamental components: autotrophs, heterotrophs, saprophytes and habitat. The first three components represent living creatures existing within the inanimate environment created by the latest component. External factors affecting the rings of the habitat chain causes all the system to be harmed. Especially unconscious management of wastes, which is defined as all kinds of materials occurred and thrown away or left as a result of any activity in Environmental Laws, has a great effect on imbalance of ecosystem and rapid exhaustion of natural resources.

As a sector having a close interrelation with environment, printing industry is bound to natural raw materials for paper, ink and printing auxiliary production. As the source of cellulose, trees are highly needed especially in paper manufacturing sector. Trees also have a fundamental role in human life as source of oxygen. During production process, paper manufacturing sites use chemical auxiliaries and pollute the environment by releasing wastewater, chemical gases and various solid wastes besides exhausting oxygen sources rapidly by using trees in production. Usage and waste of paper as an end product requires a reproduction process using raw materials and creating waste. Therefore, paper recycle has an important role in ecosystem balance in terms of causing a dramatic decline in waste production and tendency of using natural raw materials. When used and wasted without waste management, ink, plastics, bath waters of films and plates and chemicals also become hazardous wastes polluting air and water.

Global Footprint Network, a company studying on human-based consumption tendency on world scale, has stated that the amount of the sources consumed at first 7 months of 2017 is higher than the amount that can be renewed in 12 months. This means humans released carbon, fished, logged and consumed water in an amount beyond the tolerance limit of oceans and forests. [1].

Waste is defined as something lying unproductive, inhabited, or desolate. Generally all waste appears in three forms, namely: solid waste, wastewater (liquid waste), and air emission [2].

Wastes generated in the printing house must be disposed of. The disposal methods can cause a serious threat to the environment and human life [3].

Ink, paper and chemical wastes may be solid, liquid and gaseous in printing industry. Management of these wastes is highly important in terms of minimizing the harms given to human and nature besides raising recycle awareness. By integrating consumed materials in production process, we may help ecosystem to become a renewable source in frame of sustainable life principle and economic growth.

2. EMERGENCE AND RECYCLING OF PRINTING INDUSTRY WASTES

The printing industry uses various printing technologies for printing books, magazine, newspapers, business documents, catalogues, form, etc. These technologies include lithography, rotogravure, flexography, screen, letter-press, and digital technologies including inkjet and electro-photography. The use of these technologies depends on the required quality of the print, number of impressions to be printed, availability of required resources, cost of the equipment, consumables cost per unit, need to use variable content, and other factor [4].

Printing process requires various fundamental printing technologies. Raw materials and chemicals used in production generate or become waste, as water used in some printing systems.

When the waste generated causes financial loss to a company and poses a threat to the environment-air, water, and land, then it becomes a problem to society at large [5].

The waste emerging in production process of printing system should be studied, categorized and treated according to an appropriate waste management procedure.

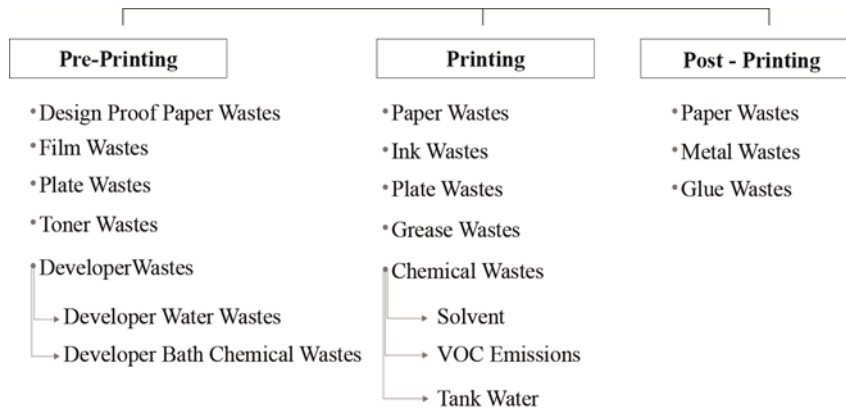


Figure 1. Printing Wastes [6], [7]

2.1. Inks

Ink is the diffusion of colouring agents in an adhesive system and transfers the image on a swage plate material. Inks generally consist of four fundamental materials; pigment, adhesive, solvent and additive agents. Liquid and badigeon inks contain pigment or colorants. Heavy metal content of this colorants pollute environment via waste inks. Titanium dioxide, chromate and molybdenum are some of the heavy metals used in printing inks.

Badigeon inks are used in offset, letterpress and sometimes screen printing systems while liquid inks are used in flexo and gravure printing systems. Solvents in liquid inks used in flexo and gravure printing systems are inflammable. Moreover, toluene in gravure ink is a toxic and inflammable material. Web offset inks also contain high levels of volatile organic compounds (VOC). When the solvents are volatilised and inks are used uncontrolled, these substances pose danger for human health [8].

According to the report of Trucost, a company providing consultancy service about environment and waste, printing plants affect environment by not only waste amount, but also greenhouse gas (disposed to be stored, burnt, reused or recycled) and volatile organic compounds (Volatile Organic Compound – VOC, except metan) they release. [9], [10].

Table 1. Sample formulations of gravure inks

General	Printing	Packaging	Water-based Printing Inks
%20 Pigment and Toner	% 8 Phthalo Blue	%33 Titanium Dioxide	% 15 Phthalo Blue
%28 Resin	% 15 Chlorinated Rubber	%22 Nitrocellulose Varnish	%47 Acrylic Resin
%47 Solvent	% 10 Phenolic Modified Resin	%37 Resin Ester Varnish	%30 Aqua
%5 Wax, Plasticiser and Additive Agents	%5 Plasticiser	%3 Plasticiser	%2 Alkali
	%1 PE Wax	%5 Wax Compounds	% 1 Foam Inhibitor
	%51 Toluene		% 2 PE Wax
	% 10 Ethyl Acetate		%3 Isopropanol

All solvents in printing inks (except water) are air contaminants. Therefore, waste printing inks should be recycled in frame of a controlled transformation procedure in order to protect human health and environment. The best method of controlled transformation is recycling or burning the solvent. While liquid inks as flexo and gravure ink solvents are generally recycled, web offset inks tend to be burnt.

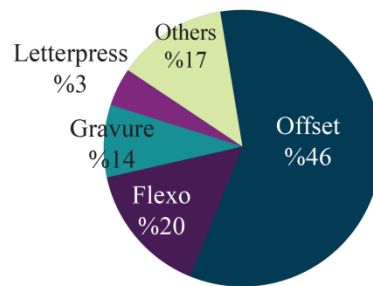


Figure 2. Ink consumption in 2012 according to worldwide printing techniques [11].

Flexo and gravure inks are recycled by a technique requiring organic solvents in printing press dryer exhaust to be imposed in a cabinet frozen by activated carbon and transferred to another cabinet to be cooled. When the exhaust is refrigerated, vapour and solvents are condensed and split into two layers and recycling process is over. Recycled solvents are re-integrated into production process by being sold or reused as a diluting solvent in printing press.

Burning: burning is the best technique to minimise final waste amount besides generating energy as an important recycling product. Moreover, burning is the most expensive recycling method [12].

Burning method aims to neutralise or shrink hygienically or, if economical, use the solid wastes for generating energy [13]. Solvents are burnt and eliminated by three methods; thermal burning, catalytic burning and cooling-condensation.

2.2. Paper / Paperboard in Press Industry

Printed papers are used in a wide range of products as books, magazines, newspapers, cardboard boxes, labels, etc. Paper is defined as printable sheets produced from pulp consisting of virgin fibres obtained from herbal cellulose via mechanic or chemical methods or fibres of used papers [14]. Pulp is the fundamental of all paper types and consists of cellulose, fibres and additive agents. Cellulose is the raw material of paper production process and obtained from trees which are at least 50% cellulose, some plants that are 98% cellulose and recycled papers.

When growth period and production volume of trees and other plants integrated in production process, it can be seen that amount of consumed trees and plants affect the ecosystem.

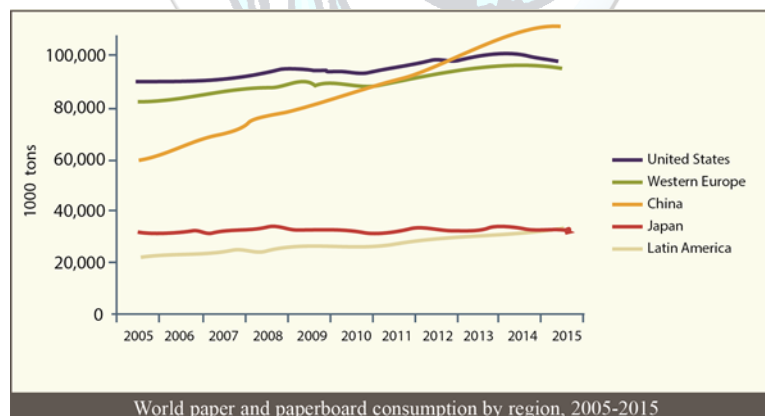


Figure 3. World paper and paperboard consumption by region, 2005 -2015 [15].

Besides a constant growth in production, it is also predicted that volume of paper and paper products will reach at 279 million tonnes in 2018 [16]. This figure shows that production process is in a huge need of raw material. When waste papers are recycled and integrated into production, less amount of raw material will be provided from environment and production costs will be reduced. Moreover, paper recycling enables to save from energy and water resources.

Recycling methods of paper wastes are defined according to paper quality and fibre structure of the papers. Each recycled kinds of paper cannot be integrated in each paper type. For example, as cardboard and corrugated cardboards cannot be used in newspaper production, paper wastes should be categorized after collected. Therefore, there are two types of processing before recycling;

- Special mechanical cleaning process not requiring cleaning the ink. They are integrated in cardboard and corrugated cardboard production processes.
- Mechanical and chemical cleaning process requiring cleaning the ink. Fibres integrated in newspaper, printing paper and carbon paper production process.

The first phase of recycling process is categorisation of papers. Categorisation process is carried out via an infrared sorting machine (this machine is developed by SORT IT European Union Research Project and used in a waste sorting plant in Linz, Austria, where papers coming from all over the Europe are sorted). Halogen lamp in the machine illuminates the wastes to be sorted. The light causes organic substances in papers to vibrate and give some kind of spectral fingerprint according to their compounds. By this means, inky and inkless products can be separated. Sorted papers are then cleaned at pulp production unit by being divided into fibres, grinded, bleached and washed. Then, fibres are transferred into machine approach unit and mixed and diluted. While this process is being carried out, the mixture is sent to pulp mixing unit after required chemicals and fillings are added. Paper machine then produces recycled paper by sieving, pressing, drying and calendaring the pulp coming in a certain thickness and width.

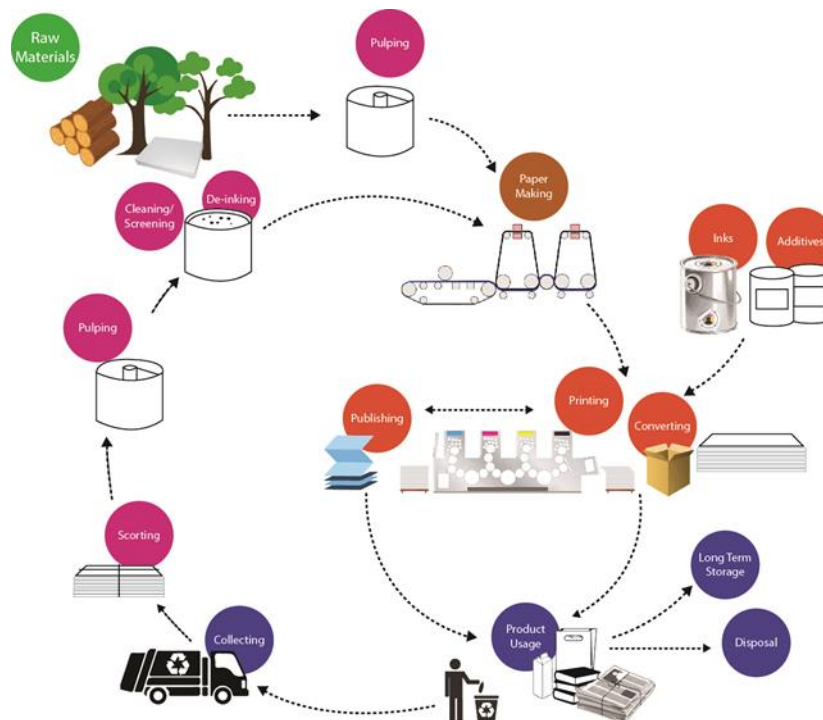


Figure 4. Recycling and Reuse of Waste Paper

Most of the digital and inkjet-printed papers were not be able to be recycled because of the surface coating enabling printing until recently. Organizations as International Association of the Deinking Industry (INGEDE) supporting researches carried out in deinking and collaborating with paper and press machine manufacturers, paper termination industry and additive agents suppliers has been seeking solutions for this problem. Digital Print De-inking Alliance (DPDA) has succeeded in most of the deinking tests on inkjet-papers recently [17]. This developments in paper recycle are shows that special papers produced for printing press can be recycled and integrated in production process in accordance with technological possibilities.

It is seen that recycling waste paper enables to save from water and energy needed for production. Figure 5 shows the advantages of paper recycling according to The State of the Paper Industry, Monitoring the Indicators of Environmental Performance-[15].

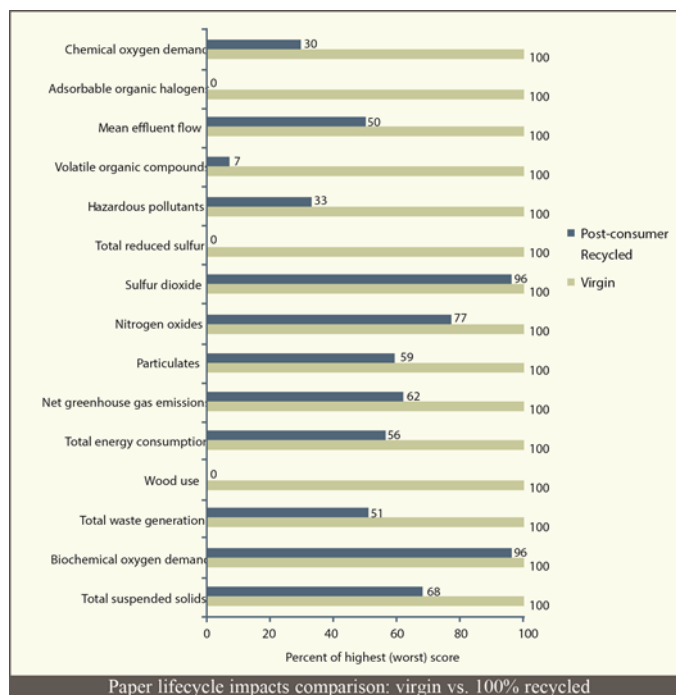


Figure 5. Paper lifecycle impacts comparison: virgin vs. 100% recycled.

2.3. Water and Chemicals

A great amount of wastewater can easily be generated during the printing process, due to the usage of chemicals that are either toxic or difficult to decompose: ink residues (containing zinc, chromium, barium, lead, manganese, benzene, dibutyl/ethyl acetates); waste fountain and cleaning solutions (spent organic solvents, including trichloroethane, methylene chloride, carbon tetrachloride, acetone, methanol); and other solvents and container residues (toluene, xylene, glycol ethers, methyl ethyl ketone, and ethanol). The greatest attention in printing industry deserves a purification and regeneration of wastewater [18].

Each phase of printing process, re-printing, printing and post-printing, generates chemical wastes. While pre-printing process generates plate bath chemicals and bath water wastes, in printing process ink, solvent, roller/plate/blanket cleaners, varnish, UV lacquer and tank water wastes and in post-printing process adhesive and varnish wastes emerge.

When the volume of printing industry is considered, the level of the damage caused by chemical wastes and water wastes can be understood better. Especially toluene, xylene, isophorone and solvents are the most hazardous chemicals. While toluene and xylene are compounds of ink, isophorone is found in some printing inks and adhesives. Solvents are chemicals used for different purposes.

Solvents are mostly used in;

- Flexo printing, gravure printing and screen printing as diluting solvent,
- Roller and blanket cleaning chemicals,
- Plate cleaning chemicals,
- Plate bath chemicals.

Chemical wastes (solvent, ink wastes or tank water wastes) should be burnt by using air filters and recycled by professional chemical waste recycling companies in accordance with related laws. Besides chemical wastes, tank water wastes and bath water wastes are released into environment in various ways and pollute the environment by going into sewage. Manufacturers should be linked to water infrastructure plants via sewage systems to exterminate wastewater. In this way, wastewater can be sorted and exterminated besides preventing contamination of underground waters, seas and potable waters.

2.4. Waste Gases

VOCs are defined as organic substances in 293,15 Kelvin (20°C) and 0,01kPa or higher vapor pressure. [19]. VOC is the abbreviation of volatile organic compound. VOCs are chemical having the potential of harming

people and human health. Some international regulations and legislation have been made and some precautions have been taken to decrease VOC emission amount and protect human health. These regulations decrease the limit the amount of solvent used in chemicals used for various purposes as pickling to 20%.

A Volatile Organic Compound (VOC) contains one or more carbon atoms and has a high vapour pressure that allows it to readily evaporate into the atmosphere. Once in the atmosphere, the compound participates in atmospheric photochemical reactions. Ground-level ozone is produced when nitrogen oxides and volatile organic compounds (VOC's) react in the presence of sunlight. This is a major component of urban smog, which, at elevated levels, presents a potential health hazard to people of all ages and possibly damages vegetation and degrades the environment [20].

A number of industrial activities make use of chemical products containing volatile organic compounds (VOCs), which are widely used mainly due to their high volatility. Among the activities that can result in the emission of such compounds in its working environments are the offset printing processes. The main indoor sources for VOCs are solvents and inks in the printing industry due to their low vapour pressure, significant amounts of toluene, xylenes, and other volatile compounds are emitted during the printing process, polluting the workplace environment. In addition, the cleaning procedures can result in exposures that are ten times higher than during other tasks because these cleaning products are petrol-based. The inks used in the offset process are made basically of a mixture of resins, vegetable or mineral oils, pigments, and solvents. The main ingredients of the conventional inks are pigments, binders, carriers and additives [21]. Volatile organic compounds (VOC emissions) consist the 98% or 99% of all toxic gas emissions generated by printing industry. VOC emissions emerge during cleaning of printing solutions, adhesives used in binding and drying phases [22].

3. WASTE MANAGEMENT

Waste management includes environment management activities as diminishing the waste at source, sorting, collecting, temporary storage, interim storage, recycling, exterminate and post-extermination control [23].

Waste management in printing industry varies according to each manufacturer activity and producing process. When pre-printing, printing and post-printing processes are considered, waste management should be applied according to raw material usage and production style. Therefore, ink wastes, paper and paper product wastes, wastewaters and chemical wastes require different waste and environment management methods.

The first aim of waste management is to prevent waste generation as much as possible or recycling the wastes. Accordingly, each manufacturer should define a system in accordance with his/her production style and raw material usage to be able to apply a waste management procedure. Figure 6 shows a general waste management sample in printing industry.



Figure 6. General waste management in printing industry

In waste management process ink wastes, wastewater and waste gases are the types requiring some precautions. This wastes contain hazardous chemicals and therefore should be eliminated after use.

The fundamental precaution is to use vegetable-based inks without heavy metals for printing and to keep the cap of the ink containers tightly closed not to contact with air. Printing process should be carried out in rooms including air tunnel to prevent emergence of waste gases. Moreover, required precautions should be taken to prevent chemicals to contact with human body.

As ink wastes, wastewater, chemical wastes and waste gases are impossible to be recycled, these should be exterminated in accordance with related laws.

Paper and paper wastes are recyclable within waste management system. Process of sorting after production, transferring to recycling plants via paper collecting companies and recycling the papers raises energy save in environment management besides diminishing raw material need to be met from nature.

4. CONCLUSION AND RECOMMENDATIONS

This study examines environment and waste management approach in printing industry. Each production step of printing process generates waste. These wastes may be categorized as solid, liquid and gaseous wastes and some are defined as hazardous wastes. Especially in preventing or recycling of hazardous wastes, printing industry should apply and appropriate waste management procedure.

Printing sector mostly generates paper and cardboard wastes. Paper and cardboards are one of the oldest and most used packaging materials and generate some of the wastes in edge trimming and sizing process, some in printing adjustment process and some in post-printing process. Most of the paper and cardboard wastes can be recycled and integrated as secondary fibres to production process after sorted, washed and deinked. This provides cellulose, the fundamental raw material of paper, to be originated from recycled papers to an extent. Recycling method of paper wastes should be defined according to paper quality and fibre structure.

The second printing material generating most waste is ink. Ink wastes emerge in post-printing phase but they are also hazardous in printing and post-printing phases, because the solvents they contain evaporates and pollutes air (except water-based inks). Therefore, inks should be recycled under control. The safest ways to recycle inks are recycling or burning the solvent they contain. While flexo and gravure inks are generally recycled, web offset inks are burnt. Besides recycling and extermination, modifying production process to prevent wastes is a method of avoiding wastes. This can be realised by use of water or vegetable-based inks in production.

VOC emissions evaporate as gaseous wastes and in hazardous waste class as toxic chemicals in printing industry. Most of the chemicals used in either pre-printing, printing or post-printing phase of each printing technique contains VOC emissions and requires some precautions. These precautions are to use water-based and organic solvents, use CTP while preparing printing press and preferring dry printing.

Waste management process should be carried out in frame of clean production techniques protecting environment and human health and aiming sustainable no waste production. Waste and environment management is also important in terms of maintaining the sustainability of ecosystem besides getting economic advantage by minimizing costs. Preventing the emergence of solid, liquid and gaseous wastes and recycling or extermination of the used products have become a necessity for protecting environment and human health.

When worldwide production volume of printing industry is considered, it can be seen that consumption may be integrated in production by collection, transfer and recycling of all types of wastes. Recycling and reuse of especially paper and cardboard wastes originated from natural raw materials diminish costs, saves energy and supports national economy. Therefore, each manufacturer should define a waste management plan considering its operation style and raw material type it uses. In frame of this plan, manufacturers should pay attention to prefer eco-friendly raw materials, minimizing waste generation in production process and recycling the generated wastes. Usage of non-recyclable and hazardous raw materials should be kept under control.

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