
| RESEARCH ARTICLE

Identify the Environmental Impact of Hazardous Materials and Chemical Waste Generated by Printmaking Process

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| ABSTRACT

Printmaking is a versatile art form with a long and rich history, evolving from a functional means of reproduction into a distinct and powerful creative medium. Its origins trace back to ancient civilizations, with its development heavily influenced by advancements in technology, chemistry and materials. A substantial amount of waste is produced while making the artworks, which may create environmental challenges. Printmaking, as both a traditional art form and a technical process, involves the extensive use of materials such as inks, solvents, acids, and metallic compounds. While these substances are essential for creative expression, their improper disposal and management have raised growing environmental and health concerns. This study investigates the types, composition, and ecological consequences of chemical and material wastes produced during printmaking activities, emphasizing their implications for environmental health. Using a qualitative and quantitative approach supported by existing environmental studies and case analyses, this paper examines common printmaking materials such as pigment based inks, volatile organic compound (VOC) containing solvents, and acidic etchants. This research indicates that solvent-based inks and cleaning agents release VOCs that contribute to air pollution and pose inhalation risks. The research aims to identify the most hazardous components within printmaking processes, analyze their potential pathways into the environment, and assess their impact on ecosystems and human well-being.

| KEYWORDS

Printmaking, Waste, Chemical, Environment, Hazardous, Materials

| ARTICLE INFORMATION

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1. Introduction

Printmaking is a creative and aesthetic branch of visual art that typically allows artists to make multiple original works of art with their philosophical aspects. The term printmaking refers to the process of making artworks by printing, normally on paper. Except in the case of monotypes, the process is capable of producing multiples of the same pieces, which is called a print. Each piece is not a copy but an original since it is not a reproduction of another work of art and is technically known as an impression. (Mursyidah Zainal Abidina, 2013)

As a vital part of the visual arts, printmaking includes various techniques such as etching, lithography, serigraphy, and relief printmaking, allowing artists to express themselves in unique ways. The printmaking process lets artists create many iterations of the same image. Throughout history, it has served as an affordable way to communicate and share art. The history of printmaking began in Han Dynasty China. The earliest known example, a woodblock print on silk, has been dated sometime during the Han Dynasty from 206 B.C. to 220 A.D. The first print on paper was made during the seventh century. (TRIBECA PRINTWORKS)

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However, beneath the colorful layers of ink and textured surfaces lies a significant environmental challenge and waste production. Printmaking studios, especially those in academic or independent creative spaces, produce a range of waste products. These include chemical solvents, ink residues, paper offcuts, and metal or polymer plates.

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 emissions. (Pelin Hayta, The Importance of Waste and Environment Management in Printing Industry, 2019). Traditional printmaking inks frequently contain pigments derived from heavy metals such as cadmium, chromium, and lead, which are persistent in the environment and bioaccumulation in living organisms. (European Chemical Agency, 2022)

Poor disposal of these materials can negatively impact human health and the environment, especially when toxic substances are involved. The disposal of waste from printmaking presents unique challenges often overlooked in creative spaces. While the art form encourages experimentation and innovation, many studios still use traditional, inconsistent, or poorly regulated waste disposal practices. These challenges arise from complex materials, limited infrastructure, and gaps in environmental awareness.

In settings like university print labs, independent studios, and community art centers, the volume and frequency of printmaking can lead to substantial waste. These environments often lack standardized disposal protocols or resources for sustainable waste management, resulting in inconsistent practices and environmental risks. Additionally, a lack of awareness and training in sustainable studio operations allows harmful habits to continue.

Printmaking produces various waste types that can harm the environment if not managed properly. This waste primarily includes leftover inks, solvents, chemical baths, cleaning agents, and used materials like paper or plates. Inks often contain pigments, binders, and solvents, some of which may have heavy metals or volatile organic compounds (VOCs) that can pollute soil and water. Solvents and cleaning chemicals, used to maintain tools and plates, release fumes that can harm air quality and pose health risks to artists. Common printmaking methods like intaglio or lithography often rely on petroleum-based inks, acid baths, solvents such as turpentine or mineral spirits, and heavy metals in etching plates. If disposed of incorrectly, these substances can alter the pH of water sources and harm aquatic life. This waste highlights the need for sustainable studio practices and responsible disposal methods to reduce printmaking's ecological impact.

From the inks and solvents used to transfer images to the discarded blocks, plates, and paper scraps, the results of the creative process can introduce pollutants into our environments. This research looks into the different types of waste generated during printmaking and emphasizes the potential environmental impact, paving the way for a better understanding of sustainable practices within this art form.

2. Methodology

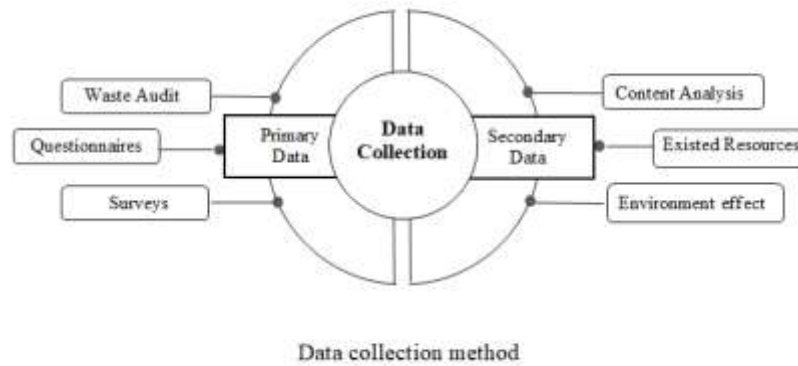
2.1 Research Method:

This investigation employs a **mixed methods research design** integrating both quantitative and qualitative approaches to comprehensively evaluate the environmental health implications of material and chemical waste in printmaking practices.

- **Qualitative Approach:** The qualitative approach involves the systematic collection and laboratory analysis of representative samples of commonly used printmaking substances, including inks, pigments, solvents, acids, and cleaning agents, to determine their chemical composition, volatility, and potential eco-toxicological impact.
- **Quantitative Component:** Quantitative component utilizes semi structured interviews and survey instruments directed at printmakers, studio managers, and environmental health professionals to elicit insights into waste management protocols, exposure control measures, and sustainability awareness within the discipline. It will work effectively for comprehending the "why" and "how" of actions and conventions.

2.2 Data Collection

The data collection methods were preferred strategically to seek and gather information. Here primary and secondary data collection methods are mentioned.



3. Literature Review:

The diverse world of printmaking employs a fascinating array of media to transfer images, each with its own unique characteristics and environmental footprint. Traditional printmaking methods often utilize wood or linoleum for relief printmaking, where the image is raised, and metal plates (copper, zinc, steel) for intaglio techniques like etching and engraving, where the image is incised.

3.1 Mediums of Printmaking

Printmaking encompasses a range of artistic techniques that involve transferring images from a matrix onto another surface, typically paper or fabric. Common printmaking mediums include;

- Relief printmaking (e.g. woodcut and linocut)
- Intaglio (e.g. etching and engraving)
- Lithography (e.g. stone, grained aluminum plate) and
- Serigraphy

Each method offers unique visual effects and expressive possibilities, and each medium employs distinct tools and processes, offering unique textures, line qualities, and expressive potential. For instance, woodcut prints are known for bold, graphic lines, while etching allows for intricate detail through the use of acid on metal plates.

3.1.1 Wood Relief:

There are various types of relief processes used in printmaking. They are classed as members of the same family because in each the actual surface from which the printing is to be done stands in relief above the rest of the block which has been cut away. (Griffiths, 1996)

The wood relief printmaking process, a form of relief printing, involves carving an image into a block of wood. The raised areas that remain after carving are inked, and then paper is pressed against the inked surface to transfer the image. (John Ross, 1991)

3.1.2 Intaglio:

In the intaglio process, the lines cut into a metal plate are filled with ink, the surface of the plate is wiped clean, and dampened paper is pressed against the plate with such pressure that it is forced into the grooves and picks up the ink. (Thompson, 2003) Normally copper, or in recent times zinc, sheets called plates are used as a surface or matrix, and the incisions are created by etching, engraving, dry point, aquatint or mezzotint, often in combination at the same time, may also be printed as intaglio plates.

In intaglio printing, the lines to be printed are cut into a metal (e.g. copper) plate by means either of a cutting tool called a burin, held in the hand, in which case the process is called engraving; or through the corrosive action of acid in which case the process is known as etching. (Ellis, 1987).

3.1.3 Lithography:

Lithography is a planographic process which means that, unlike relief or intaglio processes, it does not rely on the physical characteristics of the matrix. Instead, the matrix is created chemically to form printing and non-printing areas. Traditional lithography capitalizes on the principle that oil and water do not mix. The stone or plate surface consists of mutually exclusive hydrophilic (water loving) and hydro-phobic/lyophilic (water rejecting/grease-loving) surfaces. To make a print, the surface of the matrix is alternately sponged with water and rolled with an oil-based ink, which adheres only to the grease-loving parts. (Bill Fick, 2015)

3.1.4 Screen Print/ Serigraphy:

Early records of Japanese stencils in the West indicate the art was introduced around 1873, which lines up with the development of screen printing as it is known today. It uses a stencil method to create images. Screen Printing takes its origin from block printing which originated in China, which was the influence for Japanese Ise katagami. (Kuo, 1998)

First, the artist must build a screen by tightly stretching and attaching a finely woven fabric, usually a monofilament polyester, to a sturdy wood or metal frame. Then, the artist uses a material such as glue, paper, shellac, film stencils, or photographic processes to block out areas on the screen; the areas left open will print. The artist lays the screen on top of a sheet of paper or other material and squeegees ink across the entire screen. The ink passes through the open areas of the stencil to create the image. The artist can then make more stencils and build images in layers with different colors and designs.(About Printmaking)

3.2 Equipment for Different Printmaking Mediums

Medium	Matrix/Plate	Ink	Paper	Tools & Equipment
Relief	Wood block (woodcut), Linoleum block (linocut)	Relief ink (oil or water-based)	Printmaking paper (various types)	Wood or linoleum blocks, carving tools (gouges, knives), brayer, ink (oil-based or water-based), paper, barren or press.
Intaglio	Aluminum, Copper, Zinc, Acrylic plate	Intaglio ink (oil-based)	Dampened printmaking paper	Metal plates, etching tools (needles, burin), etching ground, acid (for etching), aquatint materials (resin), wiping materials (tarlatan), ink (oil-based), paper, press.
Lithography	Limestone or Metal plate (grained aluminum plate)	Lithographic ink (oil-based)	Printmaking paper (smooth)	Lithographic stone or plate, lithographic crayons or tusche, gum arabic, nitric acid (for stone), greasy ink, dampening sponges, rollers, press.
Screenprint/ Serigraphy	Mesh screen (silk or synthetic) with a stencil	ink (water or solvent-based)	Various (paper, fabric, etc.)	Mesh screen, stencil material (paper, film, emulsion), squeegee, ink (water-based or solvent-based), paper or fabric.

3.3 Individual Medium Process of Printmaking

Medium	Image Creation	Inking Process	Printing Process
Relief	Carving away areas to leave a raised image	Ink applied to the raised surface of the matrix.	Paper is pressed against the inked raised surface.
Intaglio	Etching, engraving, drypoint, aquatint	Ink forced into the incised lines or textures.	Dampened paper is forced into the inked recessed areas by a press.
Lithography	Drawing with greasy crayon or ink	Greasy ink adheres to the greasy image area.	Ink is transferred from the plate to paper using a press.
Screenprinting/ Serigraphy	Blocking areas of the screen with stencils or emulsion	Ink is forced through the open areas of the stencil onto the paper.	Squeegee pulls ink across the screen, transferring it through the stencil.

4. Findings

4.1 Wastes from Printmaking Mediums

Printmaking studios across various universities and art institutions generate a range of chemical and material wastes, including solvents, inks, acids, and paper, which are improperly managed.

The waste from surveyed areas and categorization is mentioned below.

Material	Identification	Categorization	Key Waste Forms
Inks	Oil-, water-based, acrylic	Hazardous (heavy metals, or volatile organic compounds (VOCs), Non-hazardous (water-based)	Leftover ink, color containers, contaminated rags
Solvents	Mineral spirits, turpentine, acetone, alcohols, soy-based cleaners.	Hazardous (petroleum-based), flammable and toxic. Less hazardous (soy-based)	Used solvents, contaminated cloths
Chemicals	Acids (Nitric acid (HNO ₃), Copper sulfate (Cu SO ₄ . 5H ₂ O) Phosphoric acid (H ₃ PO ₄), mordents	Hazardous (etching chemicals, acids, mordents, and photographic chemicals) Less toxic (diluted chemicals, or modern safer alternatives)	Spent baths, chemical sludge
Plates	Metal (zinc, aluminum, copper, steel), PVC board, ply wood, plastic wood (polyester, polystyrene)	Recyclable (clean), Hazardous (chemical residue)	Obsolete plates, test sheets
Fabrics	Cleaning rags, blankets	Contaminated (hazardous if solvent-soaked)	Used cloths
Papers	Newsprint, rag paper	Contaminated or General Waste	Ink-stained paper, scrap

4.2 Environmental Effect from the Waste of Printmaking Mediums

Printmaking, while a valuable art form, utilizes various materials and processes that can pose significant environmental and health hazards. Among these are the toxicity of certain substances and the generation of hazardous waste, particularly concerning heavy metals and Volatile Organic Compounds (VOCs).

4.2.1 Air contamination

Printmaking, while a valuable art form, utilizes various materials and processes that can pose significant environmental and health hazards. Among these are the toxicity of certain substances and the generation of hazardous waste, particularly concerning heavy metals and Volatile Organic Compounds (VOCs).

- **Heavy Metals**

Heavy metals are elements with metallic properties that can be toxic to both humans and the environment, even in small concentrations. In printmaking, they can be found in:

Heavy Metal	Description
Metal Plates	Some printmaking techniques, such as etching and engraving, use metal plates made of copper, zinc, or other metals that can leach heavy metals during the process or disposal.
Mordents and Etchants	Certain metal salts are used as mordents in coloring or as etchants in intaglio processes, potentially introducing heavy metals into wastewater.

- **Volatile Organic Compounds (VOCs)**

VOCs are organic chemicals that easily evaporate at room temperature. They are commonly found in various printmaking materials:

Volatile Organic Compounds (VOCs)	Description
Solvent-Based Inks	Many traditional printmaking inks, especially those used in serigraphy, utilize organic solvents as carriers for pigments and resins. These solvents can include alcohols, glycols, esters, hydrocarbons (like benzene, toluene, xylene), and others.
Cleaning Solvents	VOCs like turpentine, white spirit, tapem, acetone, and various alcohols are used to clean the inked plates, rollers, brushes, and other equipment.
Varnishes, Lacquers, and Coatings	Solvent-based coatings used to achieve specific finishes often contain VOCs
Adhesives	Some adhesives used in printmaking and related processes contain organic solvents that release VOCs.

4.2.2 Environmental Impacts of VOCs:

Air Pollution: Evaporation of VOCs during plate preparation, inking, and cleaning processes contributes to air pollution and ground-level ozone formation.

In the presence of sunlight and nitrogen oxides, VOCs react to form ground-level ozone, a major component of smog that harms human health and vegetation. When solvents like turpentine, acetone, or mineral spirits are used in printmaking, they easily evaporate into the air because they are volatile organic compounds (VOCs). Once in the atmosphere, these VOCs react with nitrogen oxides (NO_x) in the presence of sunlight. This process creates ground level ozone (O₃), which is a major component of smog and harmful to the environment, making the air unhealthy to breathe.

Solvent vapors (VOCs) + Nitrogen Oxides (NO_x) + Sunlight → Ozone (O₃) → Smog and Air Pollution

4.2.3 Water Contamination

Printmaking processes can significantly pollute water if waste materials are not properly handled and disposed of. The main ways this pollution occurs are:

Toxic organic chemicals are obligatory essentials for printmaking mediums, where solvents, adhesives, cleaning solutions, and certain colors are organic compounds that can be toxic. These can leach into water sources if disposed of improperly. Examples include toluene, xylene, benzene, acetone, and various alcohols. Besides heavy metals like copper, aluminum and zinc sheets/dusts are commonly used in printmaking, particularly for the processes like intaglio, lithography and serigraphy, and can pass through or interfere with water treatment plants, ultimately polluting water bodies. Moreover, etching processes use strong acids like nitric, phosphoric, and hydrochloric acids, which are corrosive and can harm aquatic life if discharged into water.

4.2.4 Soil Contamination

Printmaking waste can pollute soil through several mechanisms, primarily due to the hazardous materials often found in inks, solvents, and other process chemicals. Here are some details written below:

Soil Pollutant Elements	Description
Heavy metals	Many traditional inks, especially those used in older processes or certain specialized applications, contain heavy metals. These metals are highly toxic and can persist in the soil for a long time, contaminating it. Once in the soil, they can be taken up by plants, or be washed into groundwater, further spreading pollution.
Contaminated Sludge and Solids	Over time, ink can settle and mix with cleaning agents, forming sludge. If this sludge is not handled as hazardous waste and is disposed of improperly then it can contaminate the soil.
Volatile Organic Compounds (VOCs) and other organic chemicals	Solvents (like toluene, xylene, benzene, acetone, and alcohols), adhesives, and other organic compounds used in printmaking are often petroleum resultant. If these are disposed of on land or leak from containers, they can directly contaminate the soil.
Improperly disposed waste	If printmaking waste, such as ink soaked rags, waste inks, or cleaning solutions, is simply thrown into general landfills without proper hazardous waste treatment, the chemicals can leach into the surrounding soil.
Paper Waste (indirectly)	The vast amounts of paper waste are generated directly from the printmaking process which can also contribute to soil pollution. When waste/ misprinted paper with chemical inks is sent to landfills, the inks can eventually leach into the soil as the paper decomposes. This is especially a concern with older inks or those containing more persistent chemicals.

Conclusion

In conclusion, addressing the issue of chemical and material waste in printmaking requires both individual and institutional commitment. Artists, educators, and policymakers must collaborate to develop safer, greener methods that maintain artistic integrity while protecting ecological systems.

This study has explored the environmental and health implications of chemical and material wastes generated in printmaking processes, revealing that artistic production, while culturally and creatively valuable, poses notable ecological challenges. The findings indicate that the common materials used in printmaking, such as inks, solvents, acids, and metallic compounds, can significantly impact air, soil, and water quality when mismanaged. Volatile organic compounds (VOCs) from solvents and cleaning agents contribute to air pollution and respiratory hazards, while heavy metals persist in ecosystems, bio accumulating in aquatic organisms and entering the food chain. These pollutants not only threaten environmental stability but also pose long-term health risks to artists, students, and nearby communities.

Sustainable printmaking is essential not only as a creative choice but as an ethical and environmental responsibility. Transitioning to non-toxic, water-based inks, reducing solvent use, recycling materials, and implementing safe waste disposal methods are critical steps in minimizing ecological damage.

Ultimately, integrating waste transformation into printmaking aligns artistic practice with ecological responsibility, ensuring that creative spaces remain both environmentally conscious and artistically vibrant. The path toward eco-friendly printmaking is not only achievable but necessary to ensure that artistic expression coexists harmoniously with environmental preservation and public health protection.

Waste management is an important consideration in any artistic process, including printmaking. Properly managing waste materials from printmaking not only reduces environmental impact but can also have economic and ethical benefits and enhance the artistic practice by encouraging mindfulness, efficiency, and creativity in how artists use materials and approach their works.

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