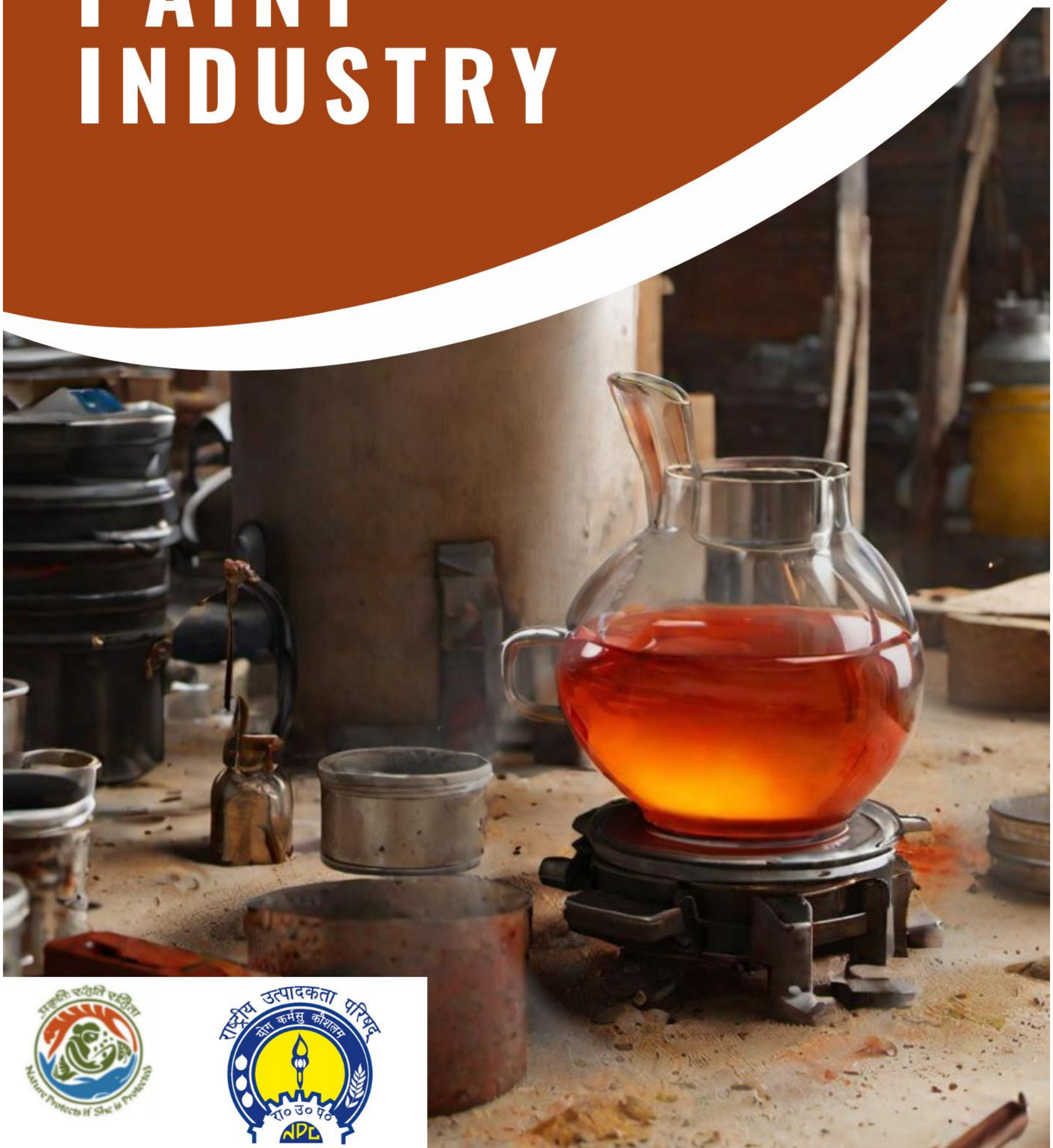
E-GUIDE FOR PAINT INDUSTRY



NATIONAL PRODUCTIVITY COUNCIL

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LIST OF ABBREVIATIONS

Abbreviation	Definition
MoEFCC	*Ministry of Environment Forest and Climate Change*
EIA	*Environment Impact Assessment*
USA	*United States of America*
SPCB	*State Pollution Control Board*
CPCB	*Central Pollution Control Board*
EMC	*Environment Management Compliance*
EC	*Environment Compliance*
QCI	*Quality council of India*
PESO	*Petroleum and Explosives Safety Organization*
COD	*Chemical Oxygen Demand*
BOD	*Biochemical Oxygen Demand*
PP	*Project Proponents*
MEC	*Monitoring evaluation Committee*
MAP	*Monitoring action plan*
CTO	*Consent to operates*

1. INTRODUCTION

1,1 Background

Human welfare depends on both the environment and their social and economic circumstances. Positive or negative changes in the socioeconomic fields will affect the earth's environment, whether they are immediate or gradual. In addition, there are many negative consequences that cannot be reversed.

A well-industrialized economy should have adequate infrastructure to support the industrial sector's growth, which drives economic activity. As part of this initiative, our Honorable Prime Minister launched the 'Make in India' campaign to encourage investment, foster innovation, develop skills, protect intellectual property, and build best in class manufacturing infrastructure. "**Make in India"** recognizes **"Ease of Doing Business"** as the most important factor to promote entrepreneurship. Several initiatives have already been taken to ease the business environment, with the aim of delicensing and deregulation of industry throughout the life cycle of a company.

On the other hand, environmental resources are those that contain intrinsic value of their own or are valuable for human long-term sustainability and use. According to strict economic thinking, most environmental resources are intangible. Furthermore, resource use and competition for scarce resources such as clean water, land and raw materials are on the rise around the world, while environmental problems such as climate change, soil degradation, and biodiversity loss are rapidly worsening. Accordingly, the Ministry of Environment, Forest and Climate Change (MoEF&CC) issued Environmental Impact Assessment (EIA) Notification in 2006 for the purpose of reviewing all relevant information about a project or activity to evaluate (and accordingly mitigate) its potential adverse effects on the ecology of the region. In this regard, our Constitution has also made provisions under Article 48A advocating for the protection of the environment, the forest, and wildlife. Furthermore, Article 51A of the Constitution of India requires Indian citizens to safeguard and improve the natural environment including forests, lakes, rivers, and wildlife. Thus, the Constitution has prioritized the protection and ensured adequate safeguard of the environment and natural resources. Therefore, MoEF&CC requires all project proponents to submit half-yearly reports to the regulator after the project has been cleared by the EAC/SEAC regarding compliance with the terms and conditions established in the terms of reference of the project.

Whenever a compliance condition is not fulfilled by the project proponent or violated, the Ministry of Environment, Forest and Climate Change, Government of India (MoEF&CC) can issue a show-cause notice.

This guidebook will serve as a tool for the project proponent to ensure compliance with the environmental conditions outlined in the project environmental clearance.

Additionally, this guidebook will provide regulatory bodies and auditors with an understanding of the sectoral aspect and provide an evaluation of effective environmental enforcement and compliance programs.

1.1 About the e-guide

The paints industry holds a significant position in the global economy, touching various aspects of our lives, from the colors that adorn our homes to the protective coatings on industrial machinery. The evolution of paints, coatings, and related products has been an intriguing journey, driven by technological advancements, environmental concerns, and changing consumer preferences. The Indian paints and coatings industry is one of the largest in the world, offering a diverse range of products, including decorative paints for residential and commercial use, industrial coatings, automotive paints, and protective coatings.

primarily through the release of volatile organic compounds (VOCs), energy-intensive manufacturing processes, and raw material extraction. These factors contribute to carbon emissions and other ecological concerns.

The shift toward sustainability can not only reduce the industry's environmental impact but also align with global efforts to create more eco-conscious products, benefitting both the environment and consumer health.

The project proponent can use this e-guide to ensure compliance with the project's environmental clearance conditions, waste minimization techniques, best practices tools and techniques/technologies/practices adopted by different industries. E-guide will give understanding of the sectoral guidance and provide an evaluation of effective environmental enforcement and compliance programs.

are included in e-guides.

2. Sectoral Profile

2.1 Background

Paint may be defined as a liquid applied in layers to protect, decorate or finish a solid surface and which hardens to form a solid coating.

Paints constitute Decorative or Architectural paints, used in households and construction purposes and Industrial paints & automotive segment paints used for equipment protection and life enhancement etc and plays an important supporting role in economy. From decorative paints that adorn our homes to industrial coatings that protect machinery and equipment, automotive paints, and specialized protective coatings, this industry plays a pivotal role across multiple sectors. Its enduring growth story is characterized by urbanization, escalating consumer demands, and a surge in construction and infrastructure development, all contributing to its ever-expanding market size. Notably, environmental consciousness has led to a profound transformation, with a significant shift towards eco-friendly paint products that boast low volatile organic compound (VOC) emissions and a commitment to sustainable raw material sourcing. In India, government initiatives such as "Housing for All" and ambitious smart city projects have fueled the sector's rapid expansion. In this fiercely competitive landscape, both domestic and international paint manufacturers like Asian Paints, Berger Paints, AkzoNobel, and PPG Industries vie for supremacy. Exploring export opportunities, this industry is not only bolstering the nation's economic growth but also making its presence felt on the global stage. However, it's not without its challenges, grappling with fluctuating raw material costs, stringent environmental regulations, and the constant pursuit of innovative and sustainable solutions in harmony with global sustainability objectives. In summation, the paint sector, with its diverse portfolio, sustainability focus, and role in India's economic development, continues to paint a vibrant and competitive landscape across the nation and beyond. There are six large-scale paint manufacturing corporate groups in India that manufactures around 60% of the total paint production by value and growing at 10-15% per annum. The rest 40% is manufactured in unorganized small-scale units constituting about 2500 units. Most of the units produce resins in-house to reduce cost of paint production. Paint constitutes a mixture of four elements - solvents, binders, pigments and additives, each having a specific function to perform and generally categorized as:

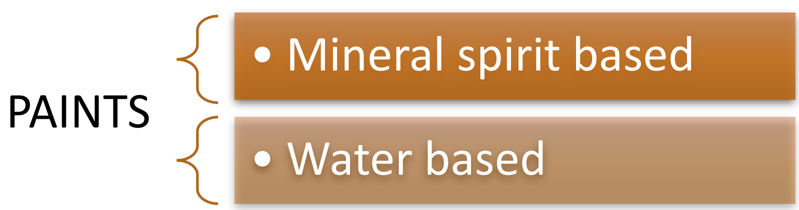


Fig 2.1 Paint categorization

2.2. Categorization of paints

- **Mineral spirit based or Solvent based** have Alkyd resin base thinned with mineral spirits
- **Water based** are water thinned.

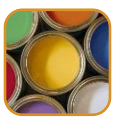
Solvent based

Exterior- Solvent thinned paints and tinting bases, enamels, primers, stains, bituminous paints.

Interior- Flat solvent thinned wall paints and tinting gas, gloss, quick drying enamels, clear finishes, solvent thinned coatings.

Water based

Exterior- Water thinned paints and tinting bases, undercoats and primers, stains and coatings.



Interior- Flat water thinned paints and tinting bases, semigloss eggshell, primers, water thinned coatings.

Table 2.1 Paints type

Based on end use, paints are generally categorized as industrial and decorative paints within each category different classifications exist.

The category of paints and related items includes paints, varnishes, lacquers, enamels, shellacs, putties, wood fillers and sealers, paint and varnish removers, paint brush cleaners, and other related paint products.

Fig 2.2 Types of paint

Classification of paints-

S.No	Classification by	Type of Paints
1	Curing mechanism	*** Physical Drying paints** *** Chemical Drying paints** *** Combination of both** *** UV curable**
2	Solvent	*** Organic solvent borne paints** *** Water borne paints**
3	Function of system component	*** Primer** *** Sealer**

		* Texture(optional) * Undercoat * Finishing coat
4	Binder component	* Oil-Based Paints * Cellulose-Based Paints * Chlorinated Rubber Paints * Vinyl Paints * Acrylic Paints * Alkyd Paints * Saturated polyester Paints * Unsaturated polyester Paints * Polyurethane resins Paints * Epoxy resin Paints * Silicone resin Paints * Urea, Benzoguanamine, and Melamine resins paints * Phenolic resins paints * Asphat, Bitumen and Pitch Paints * Silicate Paints
5	Market segment	* Architectural (decorative) paints * Heavy Duty paints * Marine or Industrial paints
6	Consumer usage	* Solvent rich paints * High solids paints * Waterborne paints * Dispersion

		* Emulsion * Waterborne wall paints * 2 component paints
7	**Mode of application**	*** Spray paints** *** Non Spray paints**

Table 2.2 Classification of paints

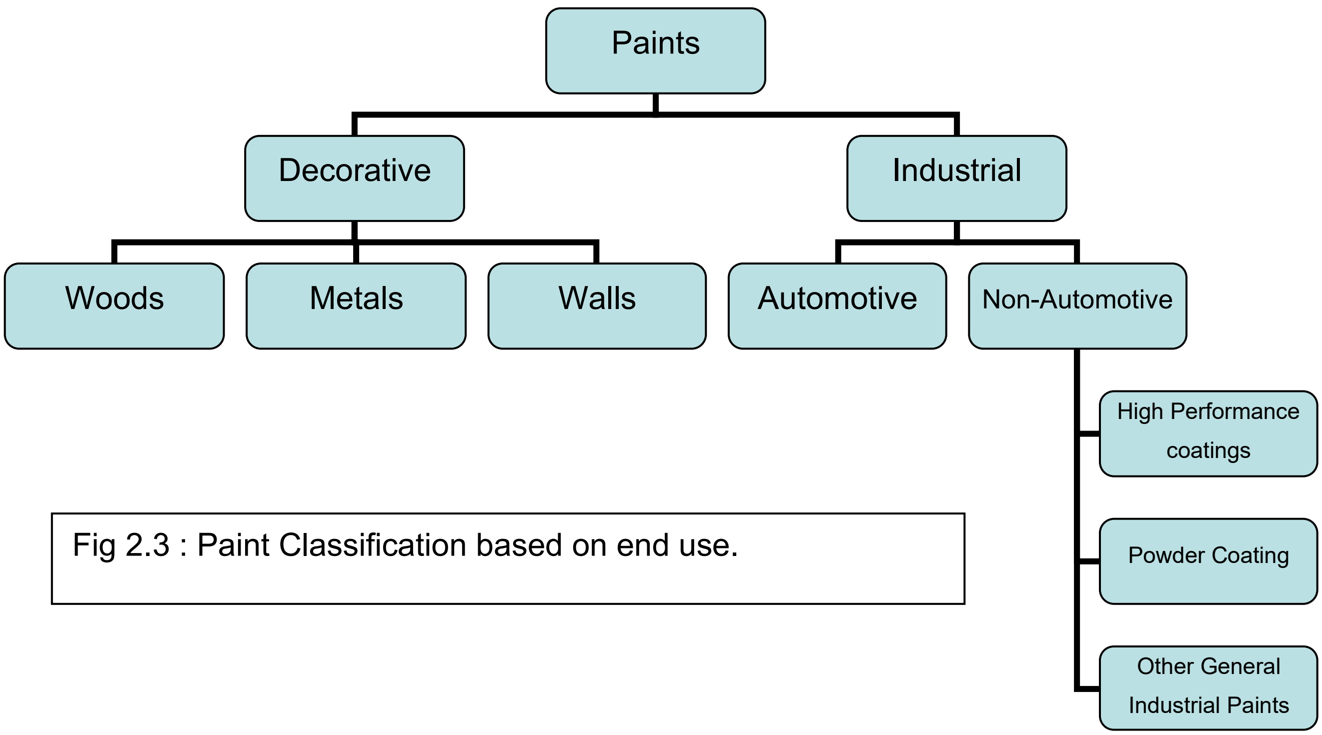


Fig 2.3 : Paint Classification based on end use.

2.3 Paint industry of India-

INDIAN MARKET

- The Indian paints and coatings industry is one of the largest in the world, with a market size of over INR 50,000 crores (approximately 6.7 billion USD).
- The Indian paint industry has been growing at a healthy rate of around 12-13% annually in recent years, driven by increasing urbanization and infrastructure development.
- Decorative paints, used in homes and commercial spaces, account for the largest share of the market, constituting approximately 75% of the industry's total sales.
- The industry is actively focused on product innovation and diversification, with the introduction of various specialized coatings, such as textured finishes, weather-resistant, and smart paints with innovative features.
- In line with global environmental concerns, Indian paint manufacturers are increasingly shifting towards low-VOC and water-based paints to reduce their environmental impact and improve indoor air quality.
- Indian paint companies are exploring export opportunities to neighboring countries and regions, contributing to the growth of India's export revenue.
- While urban markets remain a stronghold, the rural market is also experiencing notable growth, driven by initiatives like rural housing programs and increased awareness about paint products.
- Government schemes like "Housing for All" and smart city projects have significantly boosted the demand for paints in the construction and real estate sectors.
- Challenges faced by the industry include fluctuating raw material costs, regulatory compliance, and the need to develop sustainable and innovative solutions in line with global sustainability goals.

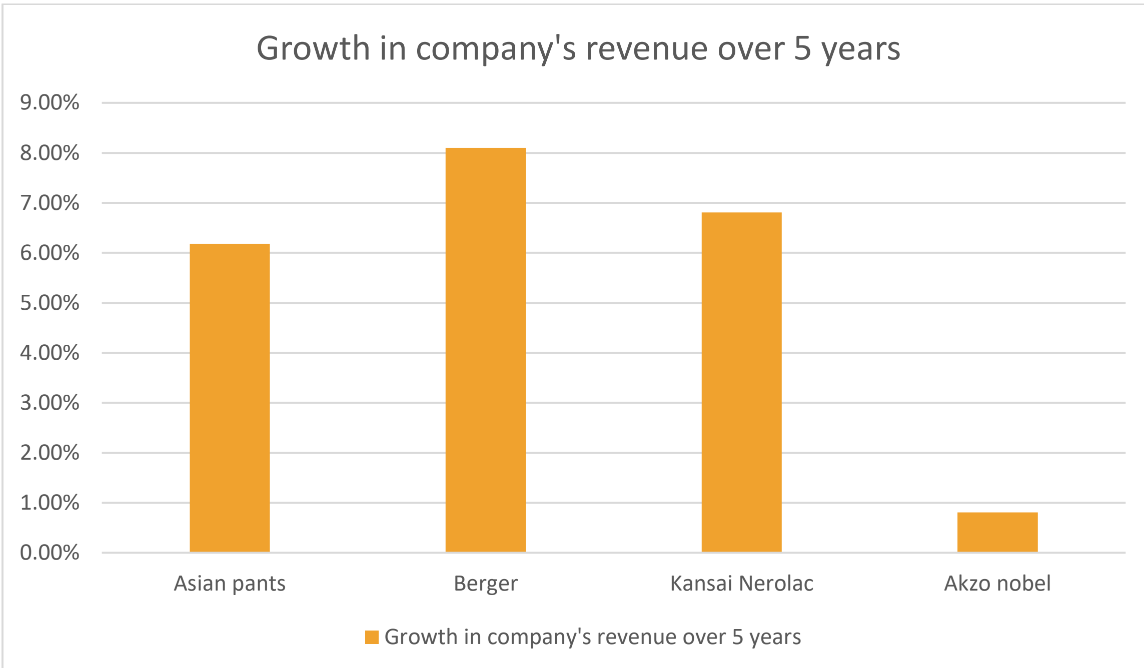


Fig 2.4- Revenue growth of top Indian paint industries

2.4 Raw Materials used in paint industry-

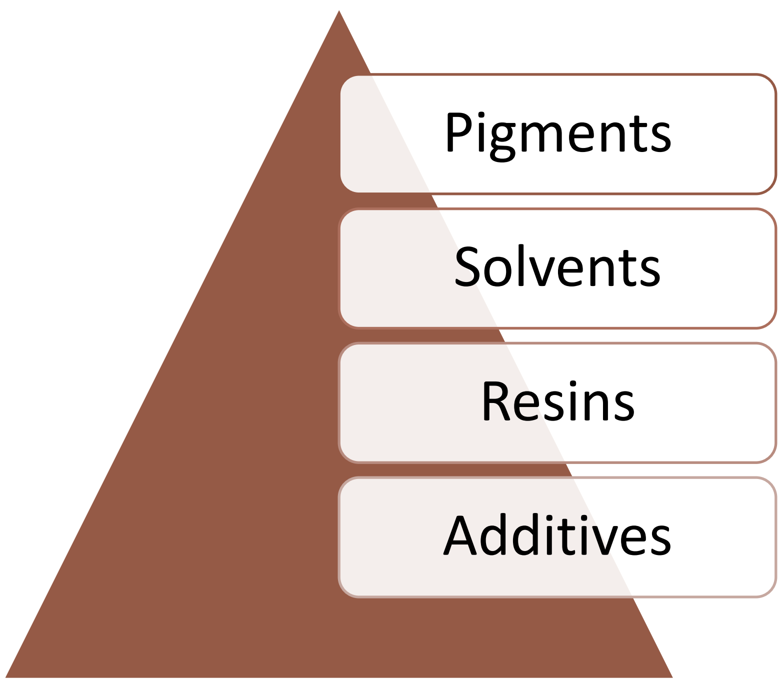


Fig 2.5- Raw material in paints industry

The raw materials used in the manufacturing of paint are organic chemicals, solvents, heavy metal-based pigments or complex resins which results in air emissions (volatile organic compounds and dust), wastewater and solid waste/ sludge (containing heavy metals and toxic organic chemicals). The primary sources of wastewater and sludge from process side are tank cleaning/ vessel washing and off-specification products and that of emissions are from mixing and processing of ingredients.

The progress in technologies has helped Paint Industry to produce lead, mercury, chromium, arsenic and antimony free paints with key players introducing lead free logo.

Pigments, solvents/carriers, extenders, and resins/binders are the primary raw ingredients used in the paint business. The majority of raw materials are locally accessible, however some may need to be imported due to specific end-use requirements or because they are not locally accessible.

The protective and general mechanical qualities of modern paint coatings are largely attributed to the resins and drying oils that make up the binder. Although some are inorganic, the majority of resins and oils used in the production of paint are organic. Three of the resins that are utilized more frequently are alkyds, acrylics, and vinyls.

The coating's color, opacity, and degree of durability are all provided by the pigments. The weather resistance of pigmented coatings is higher than that of unpigmented paints.

Pigments are used in metal primers to slow or prevent corrosion of the metal. Either organic or inorganic pigments are possible. Although organic pigments can be either natural or synthetic, the majority of organic pigments used today are produced synthetically. The majority of natural colors are iron oxides or hydroxides. The full color spectrum is covered by synthetic pigments, which can come in a variety of brilliance and opacity.

Aliphatic and aromatic hydrocarbons (such as white spirit, special boiling point (SBP) solvents, toluene, xylene, and the trimethyl benzenes) as well as alcohols, esters, ketones, esters, and ether-esters of propylene glycol are among the substances utilized as solvents. In water-based and emulsion paints, water serves as the solvent. Driers, thickeners, biocides, surfactants, dispersion agents, antifoams, and catalysts are examples of additives.

Resins or binders form the film on the surface of coating. Higher molecular binders like cellulose nitrate, poly-acrylate and vinyl chloride copolymers create films physically, while lower molecular binders like alkyd resins, phenolic resins, poly-iso-cyanates and epoxy resins form films through chemical reactions.

Solvents facilitate paint application and are called as Carrier/vehicle. Solvents can be true, latent and diluent that is completely compatible with binder, has stronger dissolving properties when mixed with true solvent and is used as blend with other two for cost efficiency respectively.

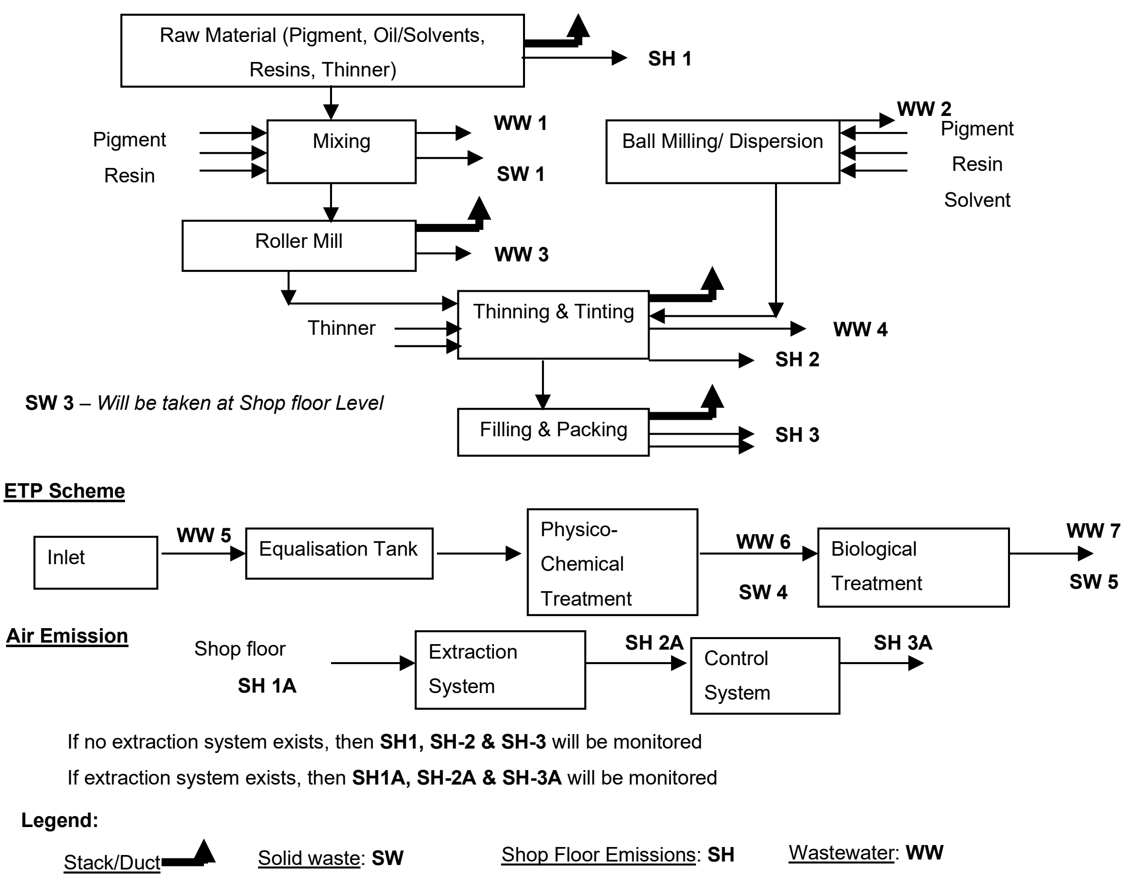
Additives are used to modify and improve the paint properties. Additives can be water based like liquor ammonia, Lutron, etc., and solvent based like benzoin, lancowax, etc.

Paint pigments are typically provided as finely ground powders that are mixed with a binder. This mixture is then adjusted to achieve particle sizes of 5-10µ for topcoat paints and approximately 50-100µ for primers. Pigments can be coloring, extending, anti-corrosive and barrier that gives color, film properties, prevents corrosion and increase impermeability respectively.

2.5 Production Process

Batch production process of paint involves the following steps

Fig 2.6- Production process



Preassembly and premix

- Liquid raw materials, including resins, solvents, oils, alcohols, and water, are combined according to a batch formulation card and mixed to create a thick substance called the base or mill base. This initial mixture is typically prepared in drums or portable tanks with mixers, with equipment selection based on batch size. After this premix stage, the mill base is further processed in a dispersion mill for grinding before returning to the premix mixer for blending. During these processes, emissions can occur during material handling, mixing, and agitating, with the extent of release influenced by factors such as solvent volatility, agitator speed, material temperature, and cover type.

Pigment grinding and premix

- The pigment grinding or milling process involves three key stages: wetting, grinding, and dispersion. During wetting, surfactants are used to wet the pigment particles, displacing contaminants like air and moisture. This process starts in the premix step. In the grinding stage, mechanical breakup of pigment clusters into isolated primary particles occurs, aiming for fine, uniform, and smooth particles permanently separated from others. The dispersion phase involves moving wetted particles into the liquid vehicle, achieving permanent particle separation through shearing forces generated by mechanical forces, viscosity, temperature, and time. Various mills are used for dispersion in the paint industry, with equipment selection depending on factors such as product type, production volume, dispersion degree, available labor, medium stability, and economics.

Product finishing

- Final product specifications are achieved in the product finishing step which consists of three intermediate stages: thinning, tinting and blending.

Thinning

- Material letdown or thinning refers to the procedure of diluting a compound mill base dispersion using solvents and/or binders to create a coating meant to yield a robust, practical film that can be easily applied to the surface. Depending on the desired product characteristics, this step may result in a notable increase in the paint volume.

Tinting

- This process involves fine-tuning the color of finished mill base dispersions. Typically, an operator extracts a paint sample as it leaves the milling equipment. This sample is then transported to the laboratory and compared against the specified color standard. To meet the color criteria, different mixtures of pigments, solvents, resins, and pastes are incorporated into the material.

Blending

- Blending operations follow the completion of the mill base dispersion, aimed at meeting product specifications. In batch processes, this can involve further milling or mixing in tanks. Material adjustments for thinning and tinting are made through top openings, agitated, and then dispensed for filling. Emissions during finishing primarily occur during tinting and thinning, influenced by solvent volatility, temperature, transfer method, and filling procedure, with higher temperatures and more volatile solvents leading to increased emissions.

Product filteration

- Filtering is essential to remove impurities like dust, resin clumps, and pigment clusters, ensuring product quality and uniformity. In media mills, filters also prevent grinding media from entering shipment containers. Filtering methods vary; some use cloth attachments on blend tank spigots, while others employ equipment like strainers or sieves. Two commonly used strainers are Russel Finex, featuring vibrating screens, and Jenag, which uses a vertical chamber with fiber filters. High-quality finishes may use wound polypropylene or resin cartridge filters, while bag filters are suitable for smaller batches. Emissions during filtering can occur when the product interacts with air, releasing VOCs.

Table 2.3- Production process

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Further Readings
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3-Environmental issues

3.1 Background

Exposure to paint and its noxious fumes, especially when extended or frequent, can lead to a range of health issues. These problems include persistent headaches, triggering allergic reactions and asthmatic episodes, as well as irritating the skin, eyes, and respiratory passages. Moreover, such exposure can exert added stress on critical organs like the heart. The World Health Organization (WHO) has reported an elevated risk of certain types of cancer, notably lung cancer, in individuals routinely in contact with paint. Danish researchers have also highlighted potential neurological damage as an additional concern.

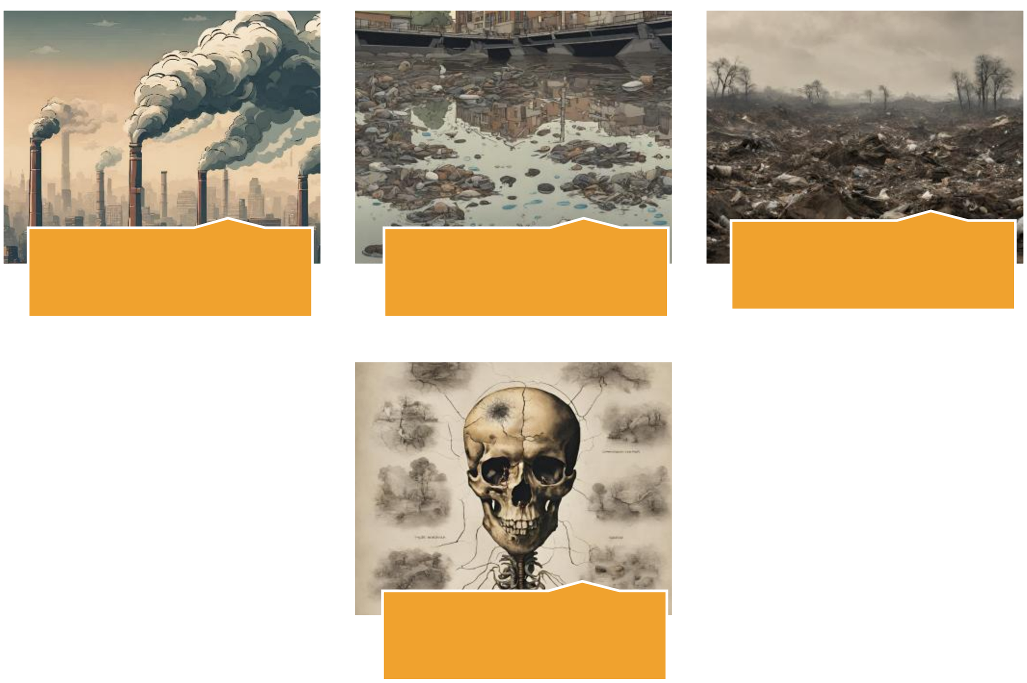


Fig3.1 Impacts of Pollution

However, the environmental ramifications of paints are significant, particularly due to the release of volatile organic compounds (VOCs) during the drying process following the application of the coating. In essence, nearly everything except the solids within standard paint formulations disperses into the air. Once in the atmosphere, VOCs contribute to the creation of ozone. In the presence of nitrogen oxides (NOx) and sunlight, VOCs interact with atmospheric oxygen to generate ozone, a highly detrimental component of the pollution we commonly refer to as smog. Ozone is notorious for its adverse effects on lung tissue, even at minimal concentrations. To mitigate the excessive production of ozone, it is vital to monitor the VOC content in paint and adhere to specific conditions.

Concerning lead in house paint, it primarily poses a threat when it is damaged or disturbed. Intact, well-maintained paint that is not peeling, chalking, or covered by lead-free alternatives is generally safe. The hazard arises when lead is present on surfaces subject to friction or impact, such as windows, doors, or railings that children might chew on. In older residential areas, high levels of lead in garden soils could be a result of lead-based paint residue. This type of paint is most commonly found on window frames, doors, skirting boards, kitchen and bathroom cupboards, exterior walls, gutters, metal surfaces, and fascias. It may also be present on interior walls, ceilings, and areas with enamel paint. Notably, both pink and red primers often contain lead, making it essential to exercise caution when dealing with surfaces coated with these paints.

In terms of the environmental impact of paint, it's important to note that the primary concerns emerge during the manufacture of its components rather than in the production of the final product.

Environmental Impact	Description

Titanium Dioxide	- Manufacture demands a substantial amount of energy (54 - 76 MJ/kg) - Emissions during production, including CO_2, N_2O, SO_2, NO_x, CH_4, and VOCs - Creation of multiple waste streams - Utilization of raw materials from scarce resources
Colored Pigments	- Diverse environmental consequences - Less severe compared to Titanium Dioxide - Note that both 'natural' and 'man-made' pigments may carry significant impacts
VOCs and Ozone	- Ozone production as an unwanted pollutant and contributor to smog - Occurs through the reaction of nitrogen oxides, carbon monoxide, and VOCs under sunlight - Health and environmental concerns linked to chemicals found in paints, including VOCs and the carcinogenic propane sulfone - Primary avenues for harm include the respiratory system and skin exposure

Table 3.1- Environmental impacts of compounds

3.2 Major Pollutants-

Polychlorinated biphenyls (PCB's)

Phenolic compounds

Volatile organic compounds

Semi-volatile organic compounds

Inorganic compounds

1. Polychlorinated Biphenyls (PCBs):

Polychlorinated biphenyls, or PCBs, are produced during the synthesis of two pigment types: diarylide pigments and phthalocyanine pigments. In the case of diarylide pigments, PCBs originate from 3,3'-dichlorobenzidine or its reaction product, 3,3'-dichlorophenyl. For phthalocyanine pigments, PCBs arise from trichlorobenzene, which is used as a solvent during the initial synthesis. PCB formation is reported to occur through the elimination of HCl in the presence of copper between two molecules of trichlorobenzene.

2. Phenolic Compounds:

One type of PCB, pentachlorophenol, is directly utilized as a raw material and preservative in certain paint formulations. Bisphenol is employed in the production of resins.

3. Volatile Organic Compounds (VOCs):

The literature mentions several VOC raw materials used in paints, including halomethane solvents such as carbon tetrachloride, chloroform, and methylene chloride, as well as aromatic solvents like toluene (methylbenzene), ethylbenzene, and xylene.

4. Semi-Volatile Organic Compounds:

Phthalate esters, which serve as plasticizers in the paint industry, and benzidine compounds like 3,3'-dichlorobenzidine are used.

5. Inorganic Compounds:

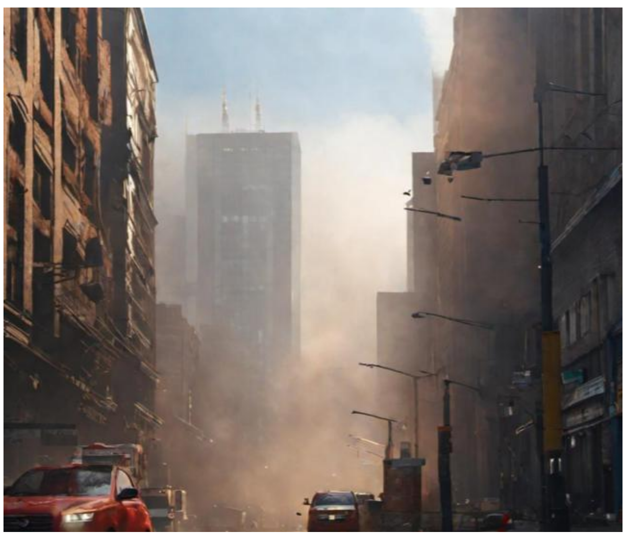
Heavy metals such as lead (Pb), zinc (Zn), and cobalt (Co), employed as pigments, driers, and extenders, are identified as potentially toxic pollutants within the paint industry's emissions.

3.3 Air Pollution-

Paint and coating manufacturing operations can give rise to a range of environmental concerns. These operations can release hazardous air pollutants, including heavy metals such as lead and chromium, which have known adverse health effects on both humans and the environment. Additionally, the use of volatile organic compounds (VOCs) in these processes, particularly during mixing and cleaning, is a source of concern. VOCs can react in the atmosphere to form ground-level ozone, a component of smog that has been linked to various respiratory problems. Furthermore, the grinding and milling of pigments in the manufacturing process generates particle pollution in the form of dust, which can contain toxic substances. Inhalation of this dust can lead to respiratory issues. To address these issues, regulations are in place at the federal, state, local, and Tribal levels to limit emissions from paint and coating manufacturing operations. Compliance with these regulations is essential to minimize the release of toxic air pollutants. Beyond human health, the environmental impact of these pollutants can be far-reaching, potentially contaminating soil and water, thereby harming ecosystems and posing risks to wildlife and human populations. Therefore, strict adherence to regulations and the adoption of environmentally friendly practices are crucial for mitigating these environmental and health risks.

The paint industry is a significant source of air pollution, primarily due to the emission of volatile organic compounds (VOCs) during various stages of paint production and application. VOCs are organic chemicals that can easily vaporize into the air, and they play a central role in paint formulations as solvents and binders. Here are key points regarding air pollution from the paint industry and VOC emissions:

1. **VOCs and Their Sources:** VOCs are emitted from the paint industry at several stages, including when raw materials are mixed, during the painting process itself, and as paint dries. Common sources of VOCs include solvent-based paints, adhesives, sealants, and surface coatings. The evaporation of VOCs from these products into the atmosphere contributes to air pollution.
2. **Health and Environmental Impact:** VOCs can have adverse health effects on humans when inhaled, including eye, nose, and throat irritation, headaches, and exacerbation of respiratory conditions. Some VOCs are also considered air toxics, with long-term exposure linked to more severe health problems. Moreover, when released into the environment, VOCs can contribute to the formation of ground-level ozone, which is a major component of smog and has been associated with respiratory issues and environmental damage.



3. **Regulation and Control:** Due to the recognized health and environmental risks associated with VOC emissions, many countries have implemented strict regulations to limit VOC content in paints and coatings. These regulations aim to encourage the development and use of low-VOC or VOC-free paint formulations. Paint manufacturers are also implementing technologies like paint booth ventilation,

emission controls, and the use of water-based or high-solids coatings to reduce VOC emissions.

4. **Consumer Choices:** Consumers can contribute to reducing VOC emissions by choosing low-VOC or VOC-free paint products for their home improvement projects. Many eco-friendly and sustainable paint options are now available in the market, which have lower VOC content and are less harmful to both indoor air quality and the environment.

3.3.1 Mitigation measures-

Transitioning away from the use of heavy metals like chromium, lead, and mercury in coating formulations is a crucial step in reducing environmental impact. Non-hazardous biocides can effectively replace mercury-containing coatings designed for antibacterial purposes. Additionally, reformulating coatings to higher solid content, opting for waterborne formulations, embracing powder coatings, or utilizing ultraviolet (UV) light-cured coatings can significantly decrease the environmental footprint of coating processes and enhance sustainability.

Consider reusing cleaning solutions or solvents, starting with dirty solvent for initial cleaning and then using clean solvent. Opt for cleaners with low levels of toxic air pollutants and volatile organic compounds (VOCs), such as water-based cleaners. Furthermore, dedicating equipment to specific products or product families with similar colors can reduce the frequency of equipment cleaning between batches, conserving resources and minimizing environmental impact.

Implementing a comprehensive waste reduction strategy, which includes reusing dust collected during pigment grinding, participating in paint exchange programs, and reworking off-specification materials, plays a pivotal role in promoting environmental sustainability within the paint and coating manufacturing industry.

Ensuring tank coverage during blending, mixing, and while awaiting material transfer is essential for environmental and safety reasons. Covering tanks effectively reduces the leakage of potentially harmful vapors and minimizes the risk of spills when transferring materials. This proactive measure enhances workplace safety, reduces emissions, and prevents environmental contamination.

Implementing a "clean as you go" policy is a valuable strategy to minimize solvent usage and enhance sustainability. When cleaning tanks, prioritize manual methods such as using wipers or squeegees over solvents. High-pressure spray hoses can also be employed for efficient cleaning while reducing solvent requirements.

Minimizing emissions of particle pollution is achieved through various measures, including using a baghouse for dust collection, employing pigments in slurry or paste form to reduce dust, and preferring sandmills for grinding and mixing raw materials. These steps collectively foster a cleaner, more environmentally friendly manufacturing process while enhancing workplace safety and air quality.

3.4 Water Pollution-

Water pollution from the paint industry in India poses a significant threat to the environment and human health. The rapid growth of the paint industry in India has led to an increase in the production and disposal of hazardous chemicals, such as heavy metals and volatile organic compounds, into water bodies. These pollutants can have detrimental effects on aquatic ecosystems and human populations that rely on these water sources for drinking and irrigation. Moreover, the improper disposal of paint wastewater can also lead to the contamination of groundwater, further exacerbating the problem. To mitigate this issue, strict regulations and enforcement mechanisms need to be put in place to ensure that paint industries properly treat their wastewater before discharging it into water bodies. Additionally, implementing stricter waste management practices and encouraging the use of eco-friendly alternatives in the paint industry can also help reduce water pollution. The paint industry in India is a major contributor to water pollution due to the release of hazardous chemicals and improper disposal of wastewater. This pollution has serious consequences for both the environment and human health.

The paint industry's primary involvement stems from its release of wastewater containing solid particles into sewage systems and wastewater treatment facilities. The production of water-based paints poses the most significant challenge in this regard.

1. **Health Risks:** Water pollution from the paint industry can result in the contamination of drinking water sources. Heavy metals like lead are particularly concerning, as they can cause severe health issues, including neurological damage, developmental disorders in children, and various other illnesses.
2. **Aquatic Ecosystem Damage:** Paint-related pollutants, especially heavy metals, can have devastating effects on aquatic ecosystems. They disrupt the balance of aquatic life, harm fish, amphibians, and aquatic plants, and ultimately lead to reduced biodiversity.
3. **Bioaccumulation:** Some heavy metals, like mercury and cadmium, have the ability to bioaccumulate in aquatic organisms. When smaller organisms ingest contaminated water, these toxic substances move up the food chain, posing risks to predators and even humans who consume fish or other aquatic species.

4. **Aesthetic and Economic Impact:** Water pollution can affect the aesthetic appeal of natural water bodies, including lakes and rivers, which may impact tourism and recreational activities. Paint pollution can also harm fisheries and aquaculture industries, leading to economic losses for communities dependent on these activities.
5. **Environmental Degradation:** The release of VOCs into water bodies can alter water chemistry and negatively impact pH levels. This can harm aquatic organisms that are sensitive to changes in water quality, further contributing to environmental degradation.
6. **Regulatory Consequences:** Water pollution from the paint industry can lead to legal and regulatory consequences. Regulatory authorities may impose fines and penalties for non-compliance with environmental standards, which can have financial implications for paint manufacturers.

3.4.1 Mitigation

Mitigation measures for water pollution in the paint industry can be achieved through a combination of new techniques, best practices, and regulatory compliance. Here are some innovative and effective strategies to reduce water pollution in the paint industry:

1. Wastewater Treatment Technologies:
    - Implement advanced wastewater treatment technologies like Membrane Bioreactors (MBRs), Reverse Osmosis (RO), and Electrocoagulation to remove contaminants and paint residues from wastewater.
    - Explore the use of biological treatment systems, such as constructed wetlands, to naturally degrade organic pollutants in the wastewater.
2. Recycling and Reuse:
    - Develop closed-loop systems that recycle and reuse water within the production process, reducing the overall water consumption and discharge.
3. Zero Liquid Discharge (ZLD):
    - Implement ZLD systems that aim to recover and reuse almost all the water used in the paint manufacturing process, leaving minimal or no liquid discharge.
4. Green Chemistry:
    - Adopt environmentally friendly, low-VOC (Volatile Organic Compounds) paint formulations to reduce the amount of harmful substances in the wastewater.
5. Nano-filtration and Ultra-filtration:
    - Use advanced filtration techniques to separate nanoparticles and smaller particulate matter from the wastewater, reducing the environmental impact.
6. Non-Toxic Pigments and Additives:

- Investigate and incorporate non-toxic pigments and additives to reduce the release of hazardous materials into the wastewater.

7. Process Optimization:
    - Optimize paint production processes to minimize the generation of waste and reduce the use of water and chemicals.
8. Spill Prevention and Response Plans:
    - Develop and implement comprehensive spill prevention and response plans to minimize accidental spills and contamination incidents.
9. Regular Monitoring and Analysis:
    - Continuously monitor the quality of wastewater and regularly analyze effluent to identify any emerging pollutants or contamination issues.
10. Education and Training:
    - Train employees on pollution prevention and best practices in handling chemicals to minimize the risk of pollution incidents.
11. Compliance with Regulations:
    - Stay updated with local, national, and international environmental regulations and ensure compliance with these standards.
12. Green Certifications:
    - Seek certifications like ISO 14001 or similar environmental management standards to demonstrate a commitment to reducing pollution and improving environmental performance.
13. Supply Chain Management:
    - Work with suppliers to ensure that the raw materials and chemicals used in paint production are environmentally friendly and compliant with regulations.
14. Community Engagement:

- Engage with the local community to address concerns and build trust. This can also involve sharing information about your pollution control efforts.

15. Research and Development:

- Invest in research and development to discover and implement new, eco-friendly paint formulations and production methods that minimize water pollution.

By incorporating these mitigation measures and innovative techniques, the paint industry can significantly reduce its impact on water pollution while promoting sustainability and environmental responsibility. Additionally, working closely with regulatory authorities and environmental organizations can help the industry stay up to date with the latest advancements and requirements in pollution control.

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Further readings
https://www.researchgate.net/publication/307477383_PAINT_POLLUTION_HARMFUL_EFFECTS_ON_ENVIRONMENT

4.WASTE MINIMIZATION

4.1 WASTE MINIMIZATION TECHNIQUES-

1. Wastewater-

In the paint industry, waste management is a critical concern, and it involves dealing with various types of waste, with a particular emphasis on the substantial volume of waste generated during equipment cleaning. These primary waste categories that are closely associated with paint manufacturing encompass a range of materials and byproducts. Firstly, there are the accidental discharge spills that may occur during manufacturing processes. Secondly, there's the wastewater generated from equipment cleaning procedures, often utilizing water or caustic solutions. Additionally, there are residues left behind from the unloading of raw materials into mixing tanks, waste solvents utilized for equipment cleaning, discarded cotton materials accumulated during equipment cleaning, and disposed filter cartridges, which are frequently linked to undispersed pigments. Moreover, pigment dust is released into the air during the unloading of pigments, posing another waste challenge. Lastly, the emission of volatile organic compounds (VOCs) from open processing equipment is a significant concern.

To manage these diverse waste streams, the paint industry typically employs one of four primary approaches: on-site reuse, on-site recycling, off-site recycling, or off-site treatment and disposal. These strategies are crucial for minimizing environmental impact, ensuring regulatory compliance, and promoting sustainable practices within the industry.

Water consumption in the production process varies widely depending on the specific products being manufactured at any given time and the extent to which water is utilized in cooling towers and floor cleaning activities. Consequently, we found no direct correlation between the types of products being produced and the quantity of water consumed. The primary source of wastewater stems from cleaning operations, and its composition depends on the chemicals and solvents used during cleaning procedures. Typically, wastewater generated by the paint manufacturing industry tends to have an alkaline pH, contain some oil and grease, and exhibit indicators such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Suspended Solids. These wastewaters may also contain trace amounts of various products. It's worth noting that BOD and COD values provide only a rough measure of organic substances in the waste. Some organic and inorganic compounds used in manufacturing are classified as hazardous materials.

Raw materials, which often include toxic substances such as chromium, copper, lead, zinc, and titanium, have minimal chances of entering the effluent stream. This is due to their careful handling, as these toxic powders are extensively mixed and blended with a range of other substances and solvents during the manufacturing process. Phthalic anhydride, a commonly used raw material in the integrated paint industry for resin production, gives rise to components in the wastewater corresponding to the constituents used in resin manufacturing, such as phenols. These components are present at elevated temperatures and are later condensed in the condensate water. While they are found in high concentrations in the condensate water, they become further diluted when mixed with other effluent streams.

In terms of wastewater sources within the paint industry:

- Caustic cleaning processes generate the most wastewater, with wash water residuals and sludge being produced. Typically, the wash water is filtered for reuse, generating sludge that is commonly disposed of at off-site landfills or used in fuel blending. Caustic wash water and sludge require proper off-site disposal at authorized facilities.

- Wastewater from the resin house results from the accumulation of water in separators. The water layer is discharged into the wastewater stream, while the upper solvent layer is reused. Water from separators is generally acidic.
- Water-based paint production, with distemper as a primary product, entails significant water usage, particularly during cleaning procedures for hoppers, grinders, and containers, contributing to high levels of suspended solids in the range of 400 to 700 mg/l.
- Solvent cleaning processes generate residuals when equipment, tanks, and secondary piping are washed with solvents or solvent blends. These solvent cleaning wastes can be recycled back into the paint production process. To extend the life of solvent wash water, many facilities employ reclamation processes, with residues from reclamation requiring proper disposal at authorized facilities.

2. Solid waste-

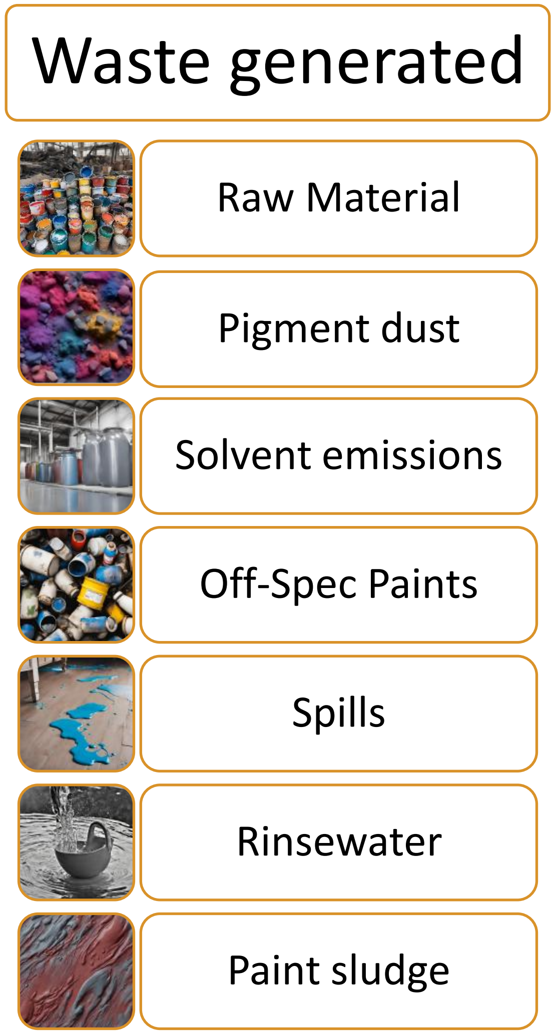

Fig4.1 Waste Generated in Paints Industry

Small quantities of quality control samples are typically kept for reference, while most off-specification paint is reintroduced into the manufacturing process. Any remaining off-specification paint that cannot be repurposed or sold as a lower-grade product is usually stored in drums or tanks and subsequently sent off-site for disposal. Disposal options include incineration, utilization in cement kilns, blending as fuel, or direct combustion. Other alternatives for off-specification paint products include entering new markets, transformation into primers or undercoats, sale to waste exchange programs, or donation to volunteer and charitable organizations.

Wastewater treatment sludge is produced through on-site treatment processes involving plant, equipment, and tank cleaning washes, as well as miscellaneous wash water streams treated physically or chemically (e.g., sludge generated during the wastewater treatment of floor washings). Due to the size and complexity of paint manufacturing facilities, on-site wastewater treatment is not common. When it does occur, sludge generated is typically transported to an off-site landfill for disposal, incineration, or use as fuel blending material. There are two types of sludge: chemical and biological. Chemical sludge results from oil and grease removal, coagulation, and settling processes. Biological sludge, on the other hand, is organic in nature and arises from biological treatment, converting non-settleable organic matter into settleable biomass. Both types of sludge can be readily dewatered on sludge drying beds.

Solid waste generated as scrap material can be categorized into metallic and non-metallic forms. Metallic solids, including drums, containers, and tins, are sold as scrap, while non-metallic solids such as cartons, plastic bags, and cotton waste are also sold. Another type of solid waste is in the form of 'paint skin.' This residue forms when paint, after proper thinning and mixing, is emptied into mild steel containers before packaging. Paint adhering to the container's sides dries and becomes paint skin, which has no practical use and is sold alongside other solid wastes.

Powders and other raw materials spilled on the floor are often collected dry and disposed of through burial. However, the landfilling of dewatered sludge from effluent treatment plants (ETP) or the burial of spilled powders can only be carried out in areas with a low groundwater table to minimize the risk of groundwater pollution. In regions where the groundwater table is high, it may be more suitable to flush powders and spilled raw materials down the drain with water, treating them alongside other collected wastewaters. This approach may increase the load of suspended solids on the ETP and slightly affect its operational costs.

It's essential to exercise caution when disposing of solid waste through burial or filling in low-lying areas, considering factors such as groundwater table depth and proximity to freshwater sources to prevent environmental contamination.

3. Waste Minimization Techniques-

Waste Streams	Minimization Methods	Benefits/Considerations
All Waste Streams	- Segregate waste based on characteristics	- Streamlined waste management system: By sorting waste based on its characteristics, the waste management process becomes more efficient, allowing for better handling and disposal.
	- Implement inventory control to prevent unnecessary purchases	- Reduced waste and costs due to inventory management: By controlling inventory, unnecessary purchases are avoided, reducing waste and associated costs.
	- Assign waste management budgets to responsible departments	- Better accountability for waste-related costs: Allocating budgets to departments generating waste ensures accountability

		and responsible handling of waste-related expenses.
Off-Spec Product	- Implement quality control systems	- Reduced off-spec production, improved efficiency: Quality control systems help identify and mitigate off-spec product generation, leading to improved production efficiency.
Volatile Organic Compounds (VOCs)	- Install airtight covers on mixing vessels	- Containment of VOC emissions during manufacturing: Airtight covers on mixing vessels help prevent the release of VOC emissions into the environment during the manufacturing process.
	- Install floating lids on solvent storage containers	- Reduced VOC emissions from storage containers: Floating lids on solvent storage containers minimize the escape of VOCs into the atmosphere, enhancing environmental compliance.
	- Keep solvent containers sealed at all times	- Prevent VOC emissions from container openings: Ensuring solvent containers are sealed when not in use minimizes VOC emissions through container openings.
	- Substitute with non-VOC cleaning solvents where practical	- Reduced reliance on VOC-containing solvents: Substituting VOC-based cleaning solvents with non-VOC alternatives contributes to a safer and more sustainable operation.

Washwater, Washsolvent, Washsolids	- Schedule long production runs of one color	- Minimized cleaning between batches: Scheduling long production runs of one color reduces the need for cleaning between batches, saving time and resources.
	- Install high-pressure, low-volume spray nozzles	- Effective waste particle removal, reduced liquid consumption: High-pressure, low-volume spray nozzles efficiently remove waste particles and decrease liquid usage during cleaning.
	- Line mixing vessels with non-stick surfaces	- Reduced waste clingage, lower liquid use: Non-stick linings in mixing vessels minimize waste adherence and liquid consumption, aiding in efficient cleaning.
	- Utilize counter-current wash and rinse systems	- Efficient two-cycle cleaning process, less liquid consumption: Counter-current wash and rinse systems optimize cleaning processes, reducing liquid consumption.
	- Allow sufficient settling time for washwater clarification	- Enhanced settling with optional additives, better recycling: Allowing adequate settling time, coupled with optional additives, improves the clarification of washwater, facilitating recycling.

	- Consider producing base products that can be tinted	- Reduced wash requirements, less post-consumer waste: Producing base products that end users can tint themselves reduces the need for washing and decreases post-consumer waste.
Raw Material Packaging	- Consider the use of removable liners in product packaging	- Possible reduction in container waste, but requires handling considerations: Employing removable liners in product packaging may reduce container waste but necessitates careful handling.
	- Purchase powders in water-soluble containers	- Reduces waste associated with certain types of packaging: Buying powders in water-soluble containers can reduce waste from packaging materials.
	- Purchase materials in bulk, rather than drums	- Decreased drum handling and evaporation losses: Procuring materials in bulk lessens the need for drum handling and reduces evaporation losses.
	- Compact non-recyclable containers	- Space and disposal cost savings: Compacting non-recyclable containers can save disposal costs and landfill space.
Dust	- Purchase powders in a paste form to eliminate dust	- Potential reduction in dust generation: Using powders in paste form may reduce dust generation during handling and processing.

Filters	- Use reusable wire mesh screens	- Opportunity to reduce waste associated with filter cleaning: Reusable wire mesh screens can be cleaned and reused, reducing filter waste.
	- Advertise and obtain used pallets	- Recycling pallets for various uses: Obtaining and using used pallets not only reduces waste but also offers recycling opportunities for pallets.
Rags	- Consider a rag cleaning service	- Rags cleaned and recycled instead of disposed: Rag cleaning services can clean and recycle rags rather than disposing of them after a single use.
Off-spec Product	- Blend off-spec products and old samples with new product	- Reutilizing off-spec products or samples: Off-spec products and old samples can be blended with new products, reducing waste and optimizing

Table 4.1- Waste minimization Techniques

4.2 Minimizing Wastewater-

The generation of wastewater in the paint manufacturing industry can vary significantly in terms of its characteristics and strength. To establish an effective wastewater treatment approach, several critical considerations should be addressed:

1. Segregation of Wastewaters: Wastewater streams should be segregated based on their distinct characteristics and strength. This initial step allows for a more focused and efficient treatment process.

2. In-Plant Control Measures: Adopting in-plant control measures is essential to reduce the volume and strength of wastewaters. This proactive approach minimizes the effluent load at its source rather than relying solely on treatment solutions.

3. Treatability Studies: Conducting treatability studies for various wastewater streams is crucial in determining the most suitable treatment system combination. This approach ensures that the chosen treatment methods align with the specific wastewater characteristics.

Effluents generated within the paint industry can typically be categorized into different types:

- **Caustic Cleaning Effluent:** This effluent is highly alkaline and requires neutralization before treatment.
- **Stiff Paint Effluent:** This type contains settleable solids that can be efficiently settled in primary clarifiers before undergoing further treatment.
- **Effluents from Other Units:** These effluents may include thermopac burner cleanings, resin house waste, and other materials. Separation is required before mixing them with other effluents.
- **Domestic Waste:** This pertains to non-industrial waste generated on-site.

Efforts to reduce wastewater generation at the source within the plant should be prioritized. This approach is geared toward decreasing the overall effluent load rather than relying solely on treatment methods. Excessive water usage not only increases effluent quantity but also inflates treatment costs, energy consumption, and product wastage.

Efforts should be made to reuse uncontaminated cooling water for purposes like floor washing or separate discharge into receiving water bodies, rather than mixing it with polluted water sent to the treatment plant.

Minimizing accidental spills and leaks is critical and can be achieved through proper equipment maintenance and personnel training. For instance, instead of washing away caustic solutions, collecting and storing them for further cleaning purposes is recommended. Similarly, water from initial cleaning of stiff paints can be collected and repurposed as process water for similar batches, reducing overall wastewater volume. Reusing rinse water for preparing alkali solutions significantly reduces the generation of caustic cleaning water.

Dry powders and raw materials spilled on floors during filling or packing should, whenever possible, be removed and disposed of as dry solid waste through burial rather than employing water for cleaning. This practice significantly reduces the pollution load of combined wastewater, subsequently reducing the required size and cost of the treatment plant. Alternatively, these materials and their containers may be sold to external parties as scrap material, further promoting waste reduction and resource utilization.

4.3 Minimization of VOC's-

Efforts to minimize VOC (Volatile Organic Compounds) emissions within the paint manufacturing industry involve various strategies, including equipment and process modifications, improved operating practices, and recycling. However, assessing the overall effectiveness and impact of these VOC-reduction methods on individual emission sources can be challenging. Many paint manufacturing facilities typically estimate their total plant emissions rather than analyzing emissions by specific processes or sources, such as filling operations, grinding operations, and cleaning processes.

1. **Equipment and Process Modifications:** Two key stages amenable to equipment and process modifications are the paint manufacturing process and equipment cleaning.
    - *Tank Lids:* Tank lids represent one of the most commonly employed equipment modifications during the manufacturing process to control VOC emissions. Mix and blend tanks play a significant role in manufacturing VOC emissions due to the extended exposure of solvent-containing materials within this equipment. To mitigate emissions, all open-top equipment can be covered during manufacturing processes.
    - *Types of Tank Lids:* Various types of tank lids, including flat and conical designs, are utilized in the industry. While flat lids offer reasonable emission control, they have inherent limitations, such as failing to form a seal with the mix tank and potential door closure issues. Conical lids, although considered more efficient, present challenges due to their added weight and bulkiness.
    - *Materials for Lids:* Tank lids are constructed from materials like plastic, wood, aluminum, or stainless steel. Concerns about safety have been raised for aluminum lids, particularly when steel scrap comes into contact with aluminum containing silicon, potentially leading to sparks and fires when in proximity to flammable vapors from solvent-containing paints.
    - *Control Efficiency of Tank Lids:* The control efficiency of tank covers varies from 40% to 96%, depending on the method used for emissions determination. These values reflect the ratio of emission reduction to uncontrolled emissions and do not factor in subsequent venting to control devices.
2. **Modified Milling Equipment:** Some paint manufacturers can reduce overall VOC emissions by upgrading older milling equipment to more efficient closed-system

alternatives, such as horizontal media mills. While horizontal mills are suitable for processing a wide range of products, they may have limitations based on viscosity requirements.

3. **Equipment Cleaning:** Equipment cleaning generates a significant portion of waste in paint manufacturing and is a major source of VOC emissions, primarily due to solvent use. Reducing the frequency and necessity of tank cleaning can help reduce emissions through various methods:
    - *Rubber Wipers:* Rubber wipers can scrape paint from tank sides, minimizing clinging paint and reducing the amount of solvent required for cleaning.
    - *High-Pressure Spray Heads:* High-pressure spray heads effectively clean process tanks, substantially reducing cleaning material usage.
    - *Teflon-Lined Tanks:* Tanks lined with Teflon reduce paint adhesion to tank surfaces, simplifying the cleaning process.
    - *Plastic Pigs:* Plastic or foam "pigs" clean paint from process pipes, reducing the need for cleaning solvent and increasing product yield.
    - *Automatic Tub Washers:* Automatic tub washers create a seal with the tank, apply a vacuum, and circulate cleaning solvent on a schedule, contributing to emissions reduction.
    - *Use of Larger Media:* Employing larger media in milling equipment simplifies rinsing, requiring less cleaning solvent. Materials like glass, ceramic media, and sand are easier to clean than steel shot.

Control of VOC emission

Treatment Technology		VOC Levels (ppmv)	Flow rate (scfm)	Removal efficiency (%)
+ Recovery Method	Adsorption	20-5000	100 to 60000	90-98
	Absorption	500 - 5000	2000 to 100,000	95-98
	Condensation	>5000	2000 to 100000	50-90
Destructive Method	Thermal oxidation	100-2000	1000 to 500000	95-99
	Catalytic oxidation	100-2000	1000 to 100000	90-95
	Bio filtration			

Table 4.2- Control of VOC's emission

1. **Recovery Methods:**

Recovery methods focus on capturing and reusing VOC emissions rather than completely eliminating them. These methods are often considered more environmentally friendly and cost-effective. A common approach in VOC recovery is adsorption, which involves the use of adsorbents to trap VOCs. Here's how it works:

- **Adsorption:** In adsorption-based VOC recovery, activated carbon or other adsorbent materials are used to capture VOC molecules from industrial exhaust streams. Research papers often explore the efficiency of different adsorbents and their capacity to capture specific VOCs. For example, a research paper may investigate the adsorption properties of various materials and their suitability for specific industrial applications.

- **Membrane Separation:** Another recovery method involves using membranes that selectively allow VOCs to pass through while separating them from the air or gas stream. Researchers might study different types of membranes and their effectiveness in VOC separation.
- **Condensation and Absorption:** In some cases, VOCs can be condensed by cooling the exhaust gases, followed by absorption into a suitable solvent. Research papers may investigate the design and performance of condensation and absorption systems for VOC recovery.
- **Biological Treatment:** Some research explores biofiltration and biotrickling filters, where microorganisms are used to metabolize VOCs, converting them into less harmful byproducts. These systems are especially relevant when dealing with dilute VOC concentrations.

2. **Destructive Methods:**

Destructive methods focus on completely eliminating VOCs from industrial emissions. These methods are typically used when VOC recovery is not feasible or when emissions need to be reduced to stringent regulatory levels. Common destructive methods include:

- **Thermal Oxidation:** Thermal oxidation, such as catalytic oxidation and thermal incineration, involves exposing VOC-laden air to high temperatures (usually above 800°C) in the presence of a catalyst or air. This breaks down VOCs into water vapor and carbon dioxide. Research papers in this area may investigate the performance of different catalysts or the optimization of thermal oxidation processes.
- **Biofiltration:** While biofiltration is primarily a recovery method, it can also be considered a destructive method when VOCs are metabolized by microorganisms to the point where they are completely mineralized

(converted to carbon dioxide and water). Research in this area may focus on improving the efficiency and stability of biofilters.

- **Chemical Scrubbing:** In chemical scrubbing, VOCs are absorbed or chemically reacted with scrubbing solutions to remove them from exhaust gases. Research papers might delve into the development of more effective scrubbing solutions or novel scrubber designs.
- **Plasma and Advanced Oxidation Processes:** These methods use non-thermal plasmas or advanced oxidation techniques to break down VOCs. Research in this area may explore the use of specific plasma technologies or advanced oxidation catalysts.

Efforts to minimize VOC emissions within the paint industry involve a combination of these strategies to improve environmental performance and reduce the industry's overall impact on air quality.

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5.1 Clearance conditions for establishment of paints industry

- The company shall comply with all the environmental protection measures and safeguards proposed in the documents submitted to the Ministry. All the recommendations made in the EIA/EMP in respect of environmental management, and risk mitigation measures relating to the project shall be implemented.
- No banned chemicals shall be manufactured by the PP. No banned raw materials shall be used in the unit. The PP shall adhere to the notifications/guidelines of the Government in this regard.
- The PP shall utilize modern technologies for capturing of carbon emitted and shall also develop carbon sink/carbon sequestration resources capable of capturing more than emitted. The implementation report shall be submitted to the IRO, MoEF&CC in this regard.
- All necessary precautions shall be taken to avoid accidents and action plan shall be implemented for avoiding accidents. The PP shall implement the onsite/offsite emergency plan/mock drill etc. and mitigation measures as prescribed under the rules and guidelines issued in the Manufacture, Storage and Import of Hazardous Chemicals (MSIHC) Rules, 1989, as amended time to time, and the Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996.
- The volatile organic compounds (VOCs)/Fugitive emissions shall be controlled at 99.97 % with effective chillers/modern technology. Regular monitoring of VOCs shall be carried out. The PP shall explore possibilities for recycling and

reusing of treated water in the unit to reduce the fresh water demand and waste disposal.

- Continuous online (24x7) monitoring system for stack emissions shall be installed for measurement of flue gas discharge and the pollutants concentration, and the data to be transmitted to the CPCB and SPCB servers. For online continuous monitoring of effluent, the unit shall install web camera with night vision capability and flow meters in the channel/drain carrying effluent within the premises.
- The storage of toxic/hazardous raw material shall be bare minimum with respect to quantity and inventory. Quantity and days of storage shall be submitted to the Regional Office of Ministry and SPCB along with the compliance report.
- Training shall be imparted to all employees on safety and health aspects for handling chemicals. Safety and visual reality training shall be provided to employees. Action plan for mitigation measures shall be properly implemented based on the safety and risk assessment studies.
- The unit shall make the arrangement for the protection of possible fire hazards during manufacturing process in material handling. Fire-fighting system shall be as per the norms.
- The solvent management shall be carried out as follows: (a) Reactor shall be connected to chilled brine condenser system. (b) Reactor and solvent handling pump shall have mechanical seals to prevent leakages. (c) Solvents shall be stored in a separate space specified with all safety measures. (d) Proper earthing shall be provided in all the electrical equipment wherever solvent handling is done. (e) Entire plant shall be flame proof. The solvent storage tanks shall be provided with breather valve to prevent losses. (f) All the solvent storage tanks shall be connected with vent condensers with chilled brine circulation.

- The storm water from the roof top shall be channelized through pipes to the storage tank constructed for harvesting of rain water in the premises and harvested water shall be used for various industrial processes in the unit. No recharge shall be permitted within the premises. Process effluent/ any wastewater shall not be allowed to mix with storm water.
- The PP shall undertake waste minimization measures as below (a) Metering and control of quantities of active ingredients to minimize waste; (b) Reuse of by-products from the process as raw materials or as raw material substitutes in other processes. (c) Use of automated filling to minimize spillage. (d) Use of Close Feed system into batch reactors. (e) Venting equipment through vapor recovery system. (f) Use of high pressure-hoses for equipment cleaning to reduce wastewater generation.
- The Project proponent shall strictly comply with the rules and guidelines issued under the Manufacture, Storage and Import of Hazardous Chemicals (MSIHC) Rules, 1989, as amended time to time, the Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996, and Hazardous and Other Wastes (Management and Trans-Boundary Movement) Rules, 2016 and other rules notified under various Acts.
- The energy source for lighting purpose shall be preferably LED based, or advanced having preference in energy conservation and environment betterment.
- The overall noise levels in and around the plant area shall be kept well within the standards by providing noise control measures including acoustic hoods, silencers, enclosures etc. on all sources of noise generation. The ambient noise levels shall conform to the standards prescribed under the Environment

(Protection) Act, 1986 Rules, 1989 viz. 75 dBA (day time) and 70 dBA (night time).

- The company shall undertake all relevant measures for improving the socio-economic conditions of the surrounding area. The activities shall be undertaken by involving local villages and administration. The company shall undertake eco-developmental measures including community welfare measures in the project area for the overall improvement of the environment.
- The project proponent shall also upload/submit six monthly reports on PARIVESH Portal on the status of compliance of the stipulated Environmental Clearance conditions including results of monitored data to the respective Integrated Regional Office of MoEF&CC, the respective Zonal Office of CPCB and SPCB. A copy of Environmental Clearance and six monthly compliance status report shall be posted on the website of the company.
- The environmental statement for each financial year ending 31st March in Form-V as is mandated shall be submitted to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently, shall also be put on the website of the company along with the status of compliance of environmental clearance conditions and shall also be sent to the respective Integrated Regional Office of MoEF&CC by e-mail.
- The project authorities shall inform the Regional Office as well as the Ministry, the date of financial closure and final approval of the project by the concerned authorities and the date of start of the project.
- Entire plant shall be flame proof. The solvent storage tanks shall be provided with breather valve to prevent losses.

- All the solvent storage tanks shall be connected with vent condensers with chilled brine circulation.
- Industrial/trade effluent shall be segregated into High COD/TDS and Low COD/TDS effluent streams. High TDS/COD shall be passed through stripper followed by MEE and ATFD (agitated thin film drier). Low TDS effluent stream shall be treated in ETP and then passed through RO system.
- Process effluent /any wastewater shall not be allowed to mix with storm water. Storm water drain shall be passed through guard pond.
- Hazardous chemicals shall be stored in tanks, tank farms, drums, carboys etc. Flame arresters shall be provided on tank farm, and solvent transfer through pumps.
- Process organic residue and spent carbon, if any, shall be sent to cement industries. ETP sludge, process inorganic & evaporation salt shall be disposed off to the TSDF.
- The Company shall strictly comply with the rules and guidelines under Manufacture, Storage and Import of Hazardous Chemicals (MSIHC) Rules, 1989 as amended time to time. All transportation of Hazardous Chemicals shall be as per the Motor Vehicle Act (MVA), 1989.
- The company shall undertake waste minimization measures as below:-

(i) Metering and control of quantities of active ingredients to minimize waste.

(ii) Reuse of by-products from the process as raw materials or as raw material substitutes in other processes.

(iii) Use of automated filling to minimize spillage.

(iv) Use of Close Feed system into batch reactors.

(v) Venting equipment through vapour recovery system.

- The green belt of 5-10 m width shall be developed in nearly 33% of the total project area, mainly along the plant periphery in downward wind direction and along road sides etc
- This Environmental clearance is granted subject to final outcome of Hon'ble Supreme Court of India, Hon'ble High Court, Hon'ble NGT and any other Court of Law, if any, as may be applicable to this project.

5.2 Emissions standard-

- Particulate matter (all process vents attached to pre mixers and mixers)- 50 mg/Nm^3

- All dust generating equipment or processes shall be provided with dust extraction arrangement.

(ii) The bag houses, etc. shall be connected to chimneys or stacks of at least twelve metres height or at least two metres above the top most point of the building, shed or plant in the industry, which so ever is higher.

(iii) The unit shall channelise shop floor or fugitive emissions through a stack of twelve metres height or at least two metres above the top most point of the building or shed or plant in the industry, which so ever is higher.

5.3 Effluent standards-

Parameter	Concentration not to exceed, (in mg/l except for pH and Bioassay)
Ph	6.5-8.5
Total Suspended Solids (TSS)	100

Bio-chemical Oxygen Demand 3 days at 27 degree Celsius	30
Phenolics as s C6H5OH	1.0
Oil and grease	10
Bio-Assay Test	90% survival in 100% effluent in 96 hours
Heavy Metals	
Lead as Pb	0.1
Chromium (Hexavalent)	0.1
Total Chromium	2.0
Copper as Cu	2.0
Nickel as Ni	2.0
Zinc as Zn	5.0
Arsenic as As	0.2
Cobalt as Co	0.2
Total Heavy metals	7.0

Table 5.1- Effluent Standards

(i) Large scale water-based plants shall meet zero liquid discharge from process section.

(ii) All Micro, Small and Medium units as per Micro, Small and Medium Enterprises Development Act, 2006 (27 of 2006) and Solvent based large scale paint units shall meet the standards as given.

5.4 Service water standards-

	Concentration not to exceed, (in mg/l except for pH and temperature)

pH	6.5-8.5
Suspended Solids	100
Oil and Grease	10
Temperature	Not more that 5°C higher than the intake water temperature

Table5.2- Service water standards

Storm Water-

(i) Storm water for a plant, a unit (having plot size at least 250 square metres) shall not be allowed to mix with scrubber water, effluent and/or floor washings.

(ii) Storm water within the battery limits of a unit shall be channelized through separate drain or pipe passing through a High Density Poly ethylene (HDPE) lines pit having holding capacity of 10 minutes (hourly average) of rainfall.

5.5 E- Guidelines for Solvent Losses

(i) the total losses of solvent should not be more than 5% of the solvent consumed, if solvent consumption less than 1000 tons/Annum; and

(ii) the solvent loss should not be more than 3% of the solvent consumed, if solvent consumption greater than 1000 tons/Annum.

Note:- The principal rules were published in the Gazette of India, Extraordinary, Part II, Section 3,Sub-section (i) vide number S.O. 844 (E), dated the 19th November, 1986 and lastly amended vide notification number G.S.R. 1025(E), dated the 9th November, 2018.

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• Performance Evaluation of Select Paint Companies in India *International Journal of Management (IJM), 11 (1), pp. 56–60, 2020*

6.GREEN BELT DEVELOPMENT

6.1 Introduction

Greenbelt development in the paints industry refers to sustainable practices aimed at reducing the environmental impact associated with the production and use of paints and coatings. This approach is crucial in today's world, where environmental conservation and sustainability have become top priorities. Here's an overview of greenbelt development in the paints industry:

1. **Environmentally Friendly Formulations**: Paint manufacturers are increasingly focusing on creating paint formulations that have lower levels of volatile organic compounds (VOCs) and hazardous chemicals. These formulations result in paints that emit fewer pollutants into the atmosphere and are less harmful to human health.
2. **Reduced Carbon Footprint**: Greenbelt development encourages the use of eco-friendly materials and processes that decrease the carbon footprint of paint manufacturing. This includes using renewable resources, reducing energy consumption, and implementing cleaner production methods.
3. **Recycling and Waste Reduction**: Greenbelt initiatives promote the recycling and responsible disposal of paint-related waste, such as empty paint cans and unused paint. By reducing waste and reusing materials, the industry minimizes its impact on landfills and resource depletion.
4. **Sustainable Sourcing of Raw Materials**: Paint manufacturers are increasingly sourcing raw materials responsibly, aiming to reduce the environmental and social impacts of resource extraction. This includes using sustainably harvested wood for paint cans and considering the ecological impact of pigments and additives.
5. **Eco-friendly Packaging**: Greenbelt development includes using recyclable and biodegradable packaging materials to minimize the environmental impact of paint

containers. Additionally, some manufacturers are moving toward innovative, sustainable packaging designs.

6. **Energy-Efficient Manufacturing**: Paint companies are investing in energy-efficient manufacturing processes, such as the use of solar panels and other renewable energy sources, as well as optimizing energy usage in production facilities.
7. **Water Conservation**: The industry is actively implementing water conservation measures, including the reduction of water usage in the production process and the responsible disposal of wastewater.
8. **Product Innovation**: Greenbelt development encourages research and innovation in the creation of high-performance, environmentally friendly paints that meet or exceed industry standards while minimizing their ecological impact.
9. **Consumer Education**: Paint manufacturers are increasingly educating consumers about the environmental benefits of using eco-friendly paints and coatings. This includes providing information about the proper disposal of paint products and containers.
10. **Regulatory Compliance**: The industry is committed to adhering to and supporting regulations and standards that promote environmental sustainability, such as those related to air quality, waste management, and emissions control.

Greenbelt development in the paints industry is a crucial step towards a more sustainable and environmentally responsible future. By adopting these practices, paint manufacturers aim to reduce their ecological footprint, conserve resources, and contribute to a cleaner and healthier planet. Consumers, in turn, have the opportunity to make eco-conscious choices when selecting paints for their projects, further promoting the adoption of environmentally friendly products.

The greenbelt in and around the industrial site is being developed for several reasons:

- To prevent land degradation and soil erosion caused by construction activities.
- To contain and reduce pollution within the industrial area, including capturing emissions, thus improving the surrounding environment's quality.
- To significantly mitigate the negative environmental impacts of the proposed industrial activity.
- To act as a barrier that reduces the intensity of generated noise.
- To increase the region's biodiversity index.
- To enhance the visual appeal of the project area.
- To maintain the ecological balance of the region.
- The following general guidelines and actions will be taken:
- Tree planting will commence during the construction phase to allow substantial growth by the project's completion. The development of the greenbelt program will be designed in accordance with natural climatic conditions and the adaptability of the chosen species.
- The species selected for greenbelt development will be native, rapid-growing, and environmentally friendly.
- An effective drainage system and proper planting techniques will be put in place.
- The plantation will be well-maintained and safeguarded by fencing to prevent grazing and logging.

6.2. APTI definition and its usage

The Air Pollution Tolerance Index (APTI) serves as a gauge for a plant's capacity to endure air pollution. It signifies that plants with a higher APTI can serve as agents for mitigating pollution, whereas those with a lower APTI can function as indicators of air pollution levels and are highly susceptible to its adverse effects, which hinder their growth due to pollutant presence (Singh & Rao, 1983).

The calculation of APTI, as outlined by Randhi and Reddy (2012), involves several factors, including the Ascorbic acid content (mg g−1) in dry weight (A), total chlorophyll content (mg g−1) (T), leaf extract pH (P), and Relative Water Content (RWC) in percentage (R).

Plants exhibiting a higher Air Pollution Tolerance Index (APTI) can be effectively employed as "bio-indicators" of air pollutants. As such, they serve as a valuable tool for monitoring and addressing pollution-related issues. Notably, the study conducted by Randhi and Reddy (2012) has classified APTI into the following categories:

- APTI Index Categories

<1	Very sensitive
1-16	Sensitive
17-29	Intermediate
30-100	Tolerant

Table6.1 APTI Index

This categorization allows for a clear understanding of a plant's ability to withstand air pollution and offers a practical means of identifying and managing areas with high pollution levels.

Significance and importance of APTI-

The Air Pollution Tolerance Index (APTI) plays a crucial role in various aspects. Plants with high APTI values act as bio-indicators, aiding in monitoring air quality and urban planning. These plants not only contribute to urban greening but also improve overall public health by reducing harmful air pollutants. APTI is invaluable for ecological restoration and biodiversity conservation, especially in areas affected by pollution or wildfires. It serves as an educational tool, raising awareness about the impact of pollution on plants and human health. APTI findings inform plant breeding and genetic engineering, enhancing the development of pollution-tolerant varieties. Regulatory agencies utilize APTI to assess the environmental impact of industrial and infrastructure projects. Long-term environmental monitoring benefits from APTI data, helping authorities adapt pollution control measures effectively. It is also a valuable component of climate change adaptation strategies by assessing the changing environmental conditions. In summary, APTI is essential for creating sustainable and resilient communities, guiding urban development, promoting environmental health, and supporting ecosystem conservation.

6.3. Plant species recommended for Paints Industry

Scientific Name	Common Name
Azadirchta indica	Neem
Sesamum indicum	Seasam
Tectona grandis	Teak wood
Cassia fistula	Indiam laburnum
Commelina benghalensis	Benghal dayflower
Chenoqodium album	Lamb's Quarters
Acacia auriculiformis	Earleaf Acacia
Acacia ferruginea	Rusty Acacia
Adina cordifolio Roxb	Indian Walnut
Borringtonio racemose Roxb	Olive Longan
Buteo monosperma Lamk	Indian Sandalwood
Colophyllum inophyilum Linn	Indian Doomba Plum
Calotropis procera	Apple of Sodom
T abernaemontana	Crape Jasmine

Withania somntfera.	Ashagandha
Sonchus asper	Prickly Sowthistle
Dolichos lablab	Hyacinth Bean
Chenopodium album	
Tnttchum aesttvam	Wheat
Calotropis gigantea	Crown Flower
Polyalthia longifolia	Mast Tree
Sesbania sp.	Sesbania
Poinciana regia	Royal Poinciana
Cassia fistula	
Terminalia arjuna	Arjuna Tree
Polyalthia longifolia	
Tectona grandis	Teak Tree
Shorea robusta	Sal Tree
Mangifera indica	Mango tree
Ficus religiosa	Peepal Tree
Ficus benghalensis	Indian Banyan
Ficus infectoria	Elephant Fig
Holoptelia integrifolia Planch	Indian Elm
Lagerstroemia sp.	
Nyctanthes arbortristis L	Parijat or Night flowering Jasmine
Thevetia nerifolia Jass	Yellow Oleander
Acacia arabica Willd	Babul tree
Hibiscus rosa sinensis Willd	Chinese Hibiscus

Morus alba	White Mulberry
Nerium indicum	Indian Oleander
Trigonella foenum-graecum	Fenugreek
Crotalaria juncea	Sunn Hemp
Cyamopsis tetragonoloba	Guar or Cluster Bean
Casuarina equisetifolia	Australian or Whistling pine
Citrus aurantium	Nebu, limu
Cocos nucifera	Coconut tree
Dryptes roxburghii	Oil tree
Duranta repens	Golden dewdrop
Eucalyptus hybrid	Mysore gum
Ficus benghalensis	Banyan tree
Ficus semicordata	Jagya dumar
Ixora arborea	Torchwood tree
Mollotus philippensis	Kamala
Polyalthia longifolia	Devdaru
Sesbania grandiflora	Swamp pea
Ziziphus mouritiana	Indian jujube
Borringtonia acutangula	Indian Oak
Borringtonia acutangula	Indian Oak
Aphono mixis polystachya	Rohituko tree
Eucalyptus citriodara	Lemon scented grass
Alstonia scholaris	Blackborad tree, Devil's tree
Ficus hispida	Umbar, kakdumur

Ficus semicordata	Jagya dumar
ficus virens	Pilkhan
Gardenia rasminoides	Anant
Grevillea robusto	Silky oak
Ixora caccinea	Rangan
Ixora undulata	Wavy leaf ixora
Lagerstroemia speciosa	Queen crape Myrtle
Mollotus philippensis	Kamala
Melia azadirach	The persian lilac
Mimusops elengi	Bakul, barsati
Murraya paniculata	Kamini
Phoenix sylvestris	The wild datepalm
Pithecellabium ducle	Manila tamarind
Polyalthia longifolia	Devdaru
Samaneo samon	Rain tree
Sesbania grandiflora	Swamp pea
Spathodeo companulata	Indian tulip tree
Syzygium cumin	Block plum
Leucaena leucocephala	river tamarind, Pardeshi Baval, Liso-Baval, Vilayati Baval, Wild Tamarind, White Baboo
Tamarindus indica	The tamarind tree
Ziziphus mouritiana	Indian jujube
Mimusops elengi	Spanish cherry
Artocarpus integrifolius	Jackfruit
Eugenia jambolana	Java plum
Aegle marmelos	Bel tree, holy fruit tree
Aphono mixis polystachya	Rohituko tree
Eucalyptus hybrid	Mysore gum

Exbucklandia poplnea	Bipli , doh
Ficus semicordata	Jagya dumar
Ixora arborea	Torchwood tree
Ixora caccinea	Rangan
Melia azadirach	The persian lilac
Polyalthia longifolia	Devdaru
Spathodeo companulata	Indian tulip tree
Leucaena leucocephala	river tamarind, Pardeshi Baval, Liso-Baval, Vilayati Baval, Wild Tamarind, White Baboo
Tamarindus indica	The tamarind tree
Ziziphus mouritiana	Indian jujube
Acacia nilotica	Indian gum, Arabic tree
Aegle marmelos	Bel tree, holy fruit tree
Ixora arborea	Torchwood tree
Sesbania grandiflora	Swamp pea
Acacia dealbata Link	Silver Wattle
Acacia dealbata Link	Silver Wattle
Acacia ferruginea	Safed Khair, Somasara
Acacia tortilis	The Umbrella thorn tree
Buchananio lonzan Spreng	Almondette tree
Casuarina equisetifolia	Australian or Whistling pine
Eucalyptus hybrid	Mysore gum
Alstonia scholaris	Blackborad tree, Devil's tree
Ficus benghalensis	Banyan tree
Ixora caccinea	Rangan
Ixora rosea	West Indian jasmine
Melaleuca leucadendron	Cajaput tree
Murraya paniculata	Kamini
Polyalthia longifolia	Devdaru
Prosopis pollida	Mesquite
Leucaena leucocephala	river tamarind, Pardeshi Baval, Liso-Baval, Vilayati Baval, Wild Tamarind, White Baboo
Ziziphus mouritiana	Indian jujube
Borringtonia acutangula	Australian wattle, Akashmone
Eucalyptus hybrid	Mysore gum

Ficus religiosa	Peepal tree
Ziziphus mouritiana	Indian jujube
Borringtonia acutangula	Australian wattle, Akashmone
Borringtonia acutangula	Indian Oak
Ficus semicordata	Jagya dumar
Garcinia talbotii	Talbot garcinia
Pithecellabium ducle	Manila tamarind
Borringtonia acutangula	Australian wattle, Akashmone
Aegle marmelos	Bel tree, holy fruit tree
Exbucklandia poplnea	Bipli , doh
Polyalthia longifolia	Devdaru
Borringtonia acutangula	Australian wattle, Akashmone
Acacia dealbata Link	Silver Wattle
Achras Sapota	Sapota, Chikoo
Aphono mixis polystachya	Rohituko tree
Azadirachta indica	Indian Lilac, Neem tree, Margosa tree
Actinodaphne angustifolia	Pisa, Tali
Borringtania racemose	Somudropho
Colophyllum inophyilum	Alexandrian laurel
Cassia siamea	Iron wood tree
Casuarina equisetifolia	Australian or Whistling pine
Citrus aurantium	Nebu, limu
Cocos nucifera	Coconut tree
Magnifera indica	Mango
Eucalyptus citriodara	Lemon scented grass
Eucalyptus hybrid	Mysore gum
Alstonia scholaris	Blackborad tree, Devil's tree
Ficus benghalensis	Banyan tree
Garcinia talbotii	Talbot garcinia
Guazma ulmifolio	Rudraksha
Ixora arborea	Torchwood tree
Melaleuca leucadendron	Cajaput tree
Melia azadirach	The persian lilac
Polyalthia longifolia	Devdaru
Sapindus emarginatus	Soapnut
Sesbania grandiflora	Swamp pea

Tectano grandis	Segun, sagwan
Ziziphus mouritiana	Indian jujube
Eugenia jambolana	Java plum
Acacia dealbata Link	Silver Wattle
Acacia farnesiana Willd	The cassia flower, Gandh, babul
Acacia mearnsii de Wild	Black wattle, Chavukku
Aphono mixis polystachya	Rohituko tree
Borringtania racemose	Somudropho
Colophyllum inophyilum	Alexandrian laurel
Calotropis gigantea	Gigantic swallow wort
Cassia pumila	Yellow Cassia
Cassia siamea	Iron wood tree
Casuarina equisetifolia	Australian or Whistling pine
Citrus aurantium	Nebu, limu
Cocos nucifera	Coconut tree
Magnifera indica	Mango
Duranta repens	Golden dewdrop
Eucalyptus citriodara	Lemon scented grass
Eucalyptus obliqua	Thaila maram
Eucalyptus hybrid	Mysore gum
Alstonia scholaris	Blackborad tree, Devil's tree
Ficus benghalensis	Banyan tree
Ficus elastica	Indian rubber tree
ficus virens	Pilkhan
Garcinia talbotii	Talbot garcinia
Guazma ulmifolio	Rudraksha
Heterophrogmo roxburghii	Warras
Ixora arborea	Torchwood tree
Kigelia africana	Sausage tree
Lagerstroemia speciosa	Queen crape Myrtle
Mollotus philippensis	Kamala
Melaleuca leucadendron	Cajaput tree
Mimusopa hexandra	Khirkhejur
Polyalthia longifolia	Devdaru
Prosopis tamarugo	Tamarugo
Sapindus emarginatus	Soapnut
Sesbania grandiflora	Swamp pea

Tectano grandis	Segun, sagwan
Trema orientalis blume	Charcoal tree
Mimusops elengi	Spanish cherry
Cyperus rotendus	Nut Grass
Artocarpus integrifolius	Jackfruit
Acacia nilotica	Indian gum, Arabic tree
Aegle marmelos	Bel tree, holy fruit tree
Buchananio lonzan Spreng	Almondette tree
Eucalyptus hybrid	Mysore gum
Ficus benghalensis	Banyan tree
Ficus semicordata	Jagya dumar
Lagerstroemia speciosa	Queen crape Myrtle
Mollotus philippensis	Kamala
Mimusops elengi	Bakul, barsati
Polyalthia longifolia	Devdaru
Prosopis pollida	Mesquite
Saraca asoka	Ashoka
Sesbania grandiflora	Swamp pea
Spathodeo companulata	Indian tulip tree
Leucaena leucocephala	river tamarind, Pardeshi Baval, Liso-Baval, Vilayati Baval, Wild Tamarind, White Baboo
Tamarindus indica	The tamarind tree
Thuja occidentalis	White cedar
Ziziphus mouritiana	Indian jujube
Artocarpus integrifolius	Jackfruit
Acacia dealbata Link	Silver Wattle
Acacia tortilis	The Umbrella thorn tree
Achras Sapota	Sapota, Chikoo
Aphono mixis polystachya	Rohituko tree
Actinodaphne angustifolia	Pisa, Tali
Casuarina equisetifolia	Australian or Whistling pine
Citrus aurantium	Nebu, limu
Cocos nucifera	Coconut tree
Magnifera indica	Mango
Eucalyptus hybrid	Mysore gum
Ficus benghalensis	Banyan tree

Ficus gibbosa	Datir, tella
Ficus semicordata	Jagya dumar
Garcinia indica	Kokam
Garcinia talbotii	Talbot garcinia
Ixora arborea	Torchwood tree
Ixora rosea	West Indian jasmine
Mammea suriga	Nagkesar
Melaleuca leucadendron	Cajaput tree
Melia azadirach	The persian lilac
Milletio peguensis	Moulmein rosewood
Mimusopa hexandra	Khirkhejur
Polyalthia longifolia	Devdaru
Thespesio populneoides	Umbrella tree
Trema orientalis blume	Charcoal tree
Ziziphus mouritiana	Indian jujube
Mimusops elengi	Spanish cherry
Eugenia jambolana	Java plum
Mimusops elengi	Bakul, barsati
Artocarpus integrifolius	Jackfruit
Borringtonia acutangula	Australian wattle, Akashmone
Ixora undulata	Wavy leaf ixora
Pithecellabium ducle	Manila tamarind
Tamarindus indica	The tamarind tree
Casuarina equisetifolia	Australian or Whistling pine
Cocos nucifera	Coconut tree
Duranta repens	Golden dewdrop
Exbucklandia poplnea	Bipli , doh
Alstonia scholaris	Blackborad tree, Devil's tree
Ficus religiosa	Peepal tree
Ficus semicordata	Jagya dumar
Ixora arborea	Torchwood tree
Ixora undulata	Wavy leaf ixora
Mollotus philippensis	Kamala
Melia azadirach	The persian lilac
Mimusops elengi	Bakul, barsati
Tamarindus indica	The tamarind tree
Trema orientalis blume	Charcoal tree

Artocarpus integrifolius	Jackfruit
Citrus aurantium	Nebu, limu
Dalbergi sisoo	Sisso
Eucalyptus hybrid	Mysore gum
Ficus benghalensis	Banyan tree
Ficus hispida	Umbar, kakdumur
Ficus semicordata	Jagya dumar
ficus virens	Pilkhan
Grevillea robusto	Silky oak
Melia azadirach	The persian lilac
Murraya paniculata	Kamini
Polyalthia longifolia	Devdaru
Prosopis pollida	Mesquite
Sesbania grandiflora	Swamp pea
Ziziphus mouritiana	Indian jujube
Acacia tortilis	The Umbrella thorn tree
Buchananio lonzan Spreng	Almondette tree
Collistemon cifrinus	Bottle brush, scarlet bottle brush
Cordia dichotoma	Seb estan fruit tree.
Ficus hispida	Umbar, kakdumur
Grevillea robusto	Silky oak
Mollotus philippensis	Kamala
Polyalthia longifolia	Devdaru
Prosopis chilensis	Mesquite
Prosopis pollida	Mesquite
Leucaena leucocephala	river tamarind, Pardeshi Baval, Liso-Baval, Vilayati Baval, Wild Tamarind, White Baboo
Ziziphus mouritiana	Indian jujube
Acacia auriculformis A cunn	Australian wattle, Akashmone
Acacia dealbata Link	Silver Wattle
Polyalthia longifolia	Ashoka, Green Champa
Azadirachta indica	Indian Lilac, Neem tree, Margosa tree
Borringtania racemose	Somudropho
Colophyllum inophyilum	Alexandrian laurel
Cassia siamea	Iron wood tree

Casuarina equisetifolia	Australian or Whistling pine
Citrus aurantium	Nebu, limu
Eucalyptus citriodara	Lemon scented grass
Eucalyptus obliqua	Thaila maram
Eucalyptus hybrid	Mysore gum
Alstonia scholaris	Blackborad tree, Devil's tree
Ficus benghalensis	Banyan tree
Ficus semicordata	Jagya dumar
Garcinia talbotii	Talbot garcinia
Guazma ulmifolio	Rudraksha
Ixora arborea	Torchwood tree
Kigelia africana	Sausage tree
Mollotus philippensis	Kamala
Melaleuca leucadendron	Cajaput tree
Mimusops elengi	Bakul, barsati
Mimusopa hexandra	Khirkhejur
Murraya paniculata	Kamini
Polyalthia longifolia	Devdaru
Sesbania grandiflora	Swamp pea
Syncorpia glomulifera	Turpentine tree
Tectano grandis	Segun, sagwan
Thespesio populneoides	Umbrella tree
Ziziphus mouritiana	Indian jujube
Mimusops elengi	Spanish cherry
Artocarpus integrifolius	Jackfruit
Borringtania racemose	Somudropho
Colophyllum inophyilum	Alexandrian laurel
Cassia siamea	Iron wood tree
Casuarina equisetifolia	Australian or Whistling pine
Derris indica	Oil tree
Ficus benghalensis	Banyan tree
Ficus semicordata	Jagya dumar
Acacia ferruginea	Safed Khair, Somasara
Borringtonia acutangula	Indian Oak
Aegle marmelos	Bel tree, holy fruit tree
Eucalyptus citriodara	Lemon scented grass
Ficus semicordata	Jagya dumar

Thuja occidentalis	White cedar
Ulmus wallichiana planch	Modred pabuna, brari
Cyperus rotendus	Nut Grass
Aegle marmelos	Bel tree, holy fruit tree
Azadirachta indica	Indian Lilac, Neem tree, Margosa tree
Magnifera indica	Mango
Dryptes roxburghii	Putranjiva
Eucalyptus citriodara	Lemon scented grass
Eucalyptus hybrid	Mysore gum
Alstonia scholaris	Blackborad tree, Devil's tree
Ficus benjaming	Chilbor, pakur
Ficus semicordata	Jagya dumar
Gardenia rasminoides	Anant
Mimusops elengi	Bakul, barsati
Murraya paniculata	Kamini
Phoenix sylvestris	The wild datepalm
Polyalthia longifolia	Devdaru
Acacia auriculformis A cunn	Australian wattle, Akashmone
Borringtonia acutangula	Indian Oak
Balanites roxburghii	Date, hingol
Casuarina equisetifolia	Australian or Whistling pine
Citrus aurantium	Nebu, limu
Cocos nucifera	Coconut tree
Eucalyptus hybrid	Mysore gum
Exbucklandia poplnea	Bipli , doh
Ficus semicordata	Jagya dumar
Ixora arborea	Torchwood tree
Polyalthia longifolia	Devdaru

Table 6.2- Plant species for paints industry

The plant species proposed are based on the guidelines for developing green belt by CPCB- March 2000

Bibliography
https://environmentclearance.nic.in/DownloadPfdFile.aspx?FileName=opS31eacKl0fwsyFnEpwb4XmNB2cZB+q6okOkunW9brm6JPcgG0F9KY+WuLRPuvK7tX07zSAWakSCpqzNhbRj8wsEi91epJZc02SuprA2Fg=&FilePath=93ZZBm8LWEXfg+HAlQix2fE2t8z/pgnoBhDlYdZCxzVPEh4a7F53Cae7tleKGoXIDiA7chYePNgRJpehWx3dLsaLaee8RS5VxBvVdCAnIMg=

7. TECHNOLOGICAL SOLUTIONS AND BEST PRACTICES

7.1 Mitigation Measures

1. Construction phase-

Environmental impacts during the construction phase can be attributed to the site preparation activity and the mobilization of workforce. The impacts of the construction phase on the environment would be basically of transient nature and are expected to wear out gradually on completion of the construction programme. However, once the construction of the project is completed and its operations started, these operation stage impacts would overlap the impacts due to the construction activities. In order to mitigate such impacts and restrict them within tolerable levels, the following measures shall be adopted:

- Proper and prior planning of approach and access roads, and appropriate sequencing and scheduling of all major construction activities.
- Adoption of appropriate soil conservation programme and its timely implementation in the proposed project site.
- Water sprinkling in the vulnerable areas to suppress the dust generated during excavation, leveling and other operations.
- Use of properly tuned construction machinery & vehicles in good working condition with low noise & emission and engines turned off when not in use.
- Control of quality of construction wastewater within the construction site by settling the construction wastewater and reusing it for construction purpose.
- Implementation of suitable disposal methods of sediment/ construction debris at designated places to avoid water logging at construction site.

• Provision of protective gears such as ear mufflers etc. for construction personnel exposed to high noise levels and locating the temporary labour sheds for construction labourers away from the construction site.

Operation phase-

• Air Pollution: DGs will be provided with individual stack height of 30 m AGL.

• Boilers will be provided with stack height of 30 m AGL.

• 1x500 kg/hr boiler will be provided with stack height of 30 m AGL.

• Thermopacks will be provided with stack height of 30 m AGL.

• Counter current scrubbers with stack height of 3 m ARL is proposed for water based, solvent based, resin & emulsion paint blocks respectively.

• 101 no of vents with bag filters / reverse jet filters are proposed for PM control.

• Water pollution: STP is proposed for treating the sewage generated and treated sewage will be used for green belt development within the industry.

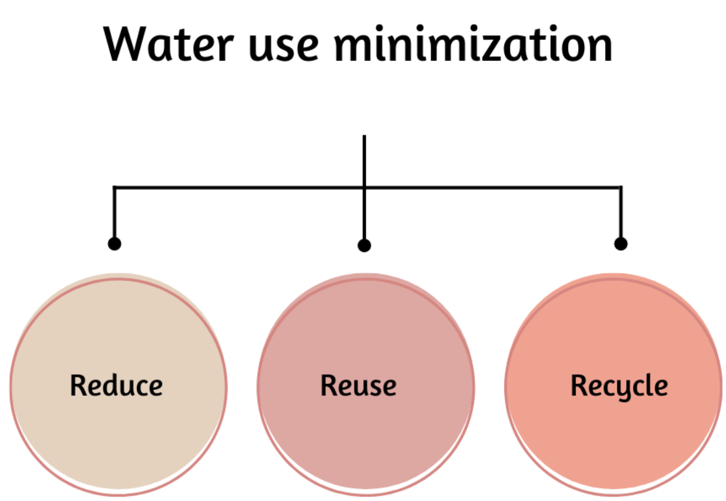

Fig7.1 Water use minimization

ETP with ZLD scheme is propsoed to treat the effluent and recycle for utilities.

• Storm water will be managed and controlled within the premises and utilized for rain water harvesting. The excess flow will be connected to the stormwater drain of SIPCOT.

• Solid and Hazardous waste: Municipal solid wastes will be segregated and organic waste will be treated in OWC. Hazardous waste will be disposed to TNPCB authorized TSDF/recyclers as applicable.

7.2 Advancement in technologies

A) The realm of nanotechnology, which delves into materials smaller than 100 nanometers, is making remarkable strides in the field of paint and coatings. An intriguing example is the advent of self-cleaning paint. By introducing nano-scale titanium dioxide into paint formulations, companies can create finishes that scarcely, if ever, require cleaning. These minuscule particles confer unique properties to paint, enabling them to interact with light to either repel or retain water droplets. This reduces surface friction, making it a breeze to repel dirt and maintain a clean, pristine appearance, whether it's on your car or your walls.
B) Nanotechnology doesn't stop at dirt resistance; it also ventures into the domain of microbial resistance. Researchers have discovered that incorporating silver nanoparticles into paint can exterminate microbes on contact, ensuring surfaces remain sterile without frequent disinfection. While the medical industry has eagerly embraced this innovation, its potential extends to various other domains.
C) Innovative painting technologies are promoting environmental consciousness. Take solar paint, for instance, which contains tiny light-sensitive particles that harness sunlight

and convert it into energy. Although it requires some wiring for energy capture, most of the installation process is as simple as painting a wall. With solar paints, you can effectively transform your roof or walls into expansive solar panels. While this technology may not match the efficiency of traditional solar panels yet, it can complement them, contributing to cleaner energy production and an environmentally friendly future.

D) Waterproofing paints have evolved, now incorporating two-component acrylic polymer-modified white cement. These paints feature water-soluble crystalline microstructures that penetrate the cement matrix deeply, effectively safeguarding against moisture damage.

E) Paint manufacturers are rolling out emulsions that incorporate cross-linking polymers and fine pigments, yielding highly washable paint. This attribute is a boon for households with pets and creative young ones who may occasionally use walls as their canvas.

F) Paint companies are simplifying the color selection process for consumers by introducing software that enables experimentation with various color schemes on photographs of their homes. This intuitive tool allows homeowners to make informed choices about their preferred color combinations before the actual painting begins.

G) In an era of visualizing before realizing, painting companies are investing in 3D visualization technology. This innovation empowers prospective homeowners to see how a specific shade or a blend of colors might transform the interior and exterior of their homes. This informed decision-making tool simplifies the process of creating the perfect living space.

7.3 Best Practices for paints industry

1. The majority of non-conforming (off-spec) paint is generated by small specialty paint shops. Given that the production of such paints is costlier, and they command a higher market price, most off-spec paint is reprocessed to transform it into a marketable product.

With an inherent economic incentive to minimize off-spec paint production, the following strategies are commonly employed: Maximizing the use of dry cleanup methods, unless sludge from wet cleanup can be repurposed as a marketable product; reducing wastewater volume by closing floor drains and discouraging unnecessary washdowns by employees; and implementing measures such as volume-limiting hose nozzles, utilizing recycled water for cleanups, and ensuring active supervisory involvement.

2. Inorganic pigments, which may include heavy metals and, thus, fall under the hazardous category, are commonly packaged separately in bags. These bags typically retain around an ounce or two of pigment after emptying. Empty containers that held hazardous waste materials like solvents and resins are usually cleaned or sent for recycling back to the original raw material manufacturer or a local drum recycling facility. Various waste reduction methods are employed for bags and packaging, such as dissolving or mixing empty bags with the paint, a technique often used for handling substances like mercury compounds and paint fungicides. However, this method isn't suitable for high-quality, smooth finish paint production as it can affect film formation and increase filter waste. Other strategies include using rinseable/recyclable drums with plastic liners instead of paper bags, segregating hazardous and non-hazardous waste, and collecting hazardous materials in plastic bags stored in a dedicated container for subsequent collection.

3. Volatile organic compounds (VOCs) pose emission concerns during the handling of resins and solvents, often in open equipment like mixing tanks. Retrofitting such equipment is costly. To tackle this, measures such as using paste-form pigments in recyclable drums, employing dedicated baghouse systems for dust collection, and following good operating procedures, like covering open vessels and reducing splashes, can mitigate VOC emissions. Dedication of process lines and equipment also minimizes cleaning needs, but smaller paint facilities may face challenges in implementing these practices due to batch schedules and same-day shipment demands.

4. To minimize waste and costs, it's advisable to use smaller cartridges, reducing paint loss and capital investment in filters. If frequent filter clogging is an issue, it's best to focus on improving pigment dispersion rather than increasing filter area. Viable alternatives to cartridge filters include bag filters and metal mesh filters, which come in very fine micron sizes and can be cleaned and reused. However, to ensure minimal waste, the handling of cleaning waste and recycling would need to be considered before transitioning to these filters.

5. Invest in energy-efficient technologies to reduce the amount of energy used to produce paints and set targets for reducing greenhouse gas emissions and achieving net zero emissions. This can help to reduce the climate impact of the paints industry.

6. In paint manufacturing, a significant variety of solvents is employed, with the majority being reclaimed and thus not discharged into wastewater streams. When it comes to oil paints, solvents are introduced within enclosed grinders, significantly minimizing solvent loss through evaporation. During the production of resins and varnishes, elevated temperatures lead to the evaporation of added solvents. These solvent vapors, along with water vapors produced through chemical reactions, are condensed and collected in a separator. The solvent layer is separated and can be reused in subsequent batches.

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Further Readings
https://www.paint.org/coatingstech-magazine/articles/paint-and-coatings-technologies-to-watch-for-in-2021/

8. Success Stories in Paints industry

8.1. Asian Paints-

Asian Paints is a multinational company that manufactures, sells, and distributes paints, coatings, home decor items, bath fittings, and offers related services. The company was founded in 1942 by four friends Champaklal Choksey, Chimanlal Choksi, Suryakant Dani, and Arvind Vakil in Mumbai, Maharashtra. Asian Paints has maintained its reputation of being the best paint company among Indian households for generations. It is Asia's third-largest paint company and India's leading one[2].

Asian Paints has been successful in creating a strong brand with a technology-driven, highly efficient supply chain. The company has differentiated its products over 75 years in India and has been the only company to deliver a CAGR of +20% for six decades in the entire world

The **Business Responsibility and Sustainability Report** of Asian Paints for the financial year 2021-22 highlights:

- The report highlights the company's efforts to reduce its carbon footprint by adopting renewable energy sources and implementing energy-efficient technologies
- Asian Paints has also taken steps to reduce its water consumption by implementing water conservation measures and recycling wastewate
- The company has implemented a circular economy model that aims to reduce waste generation and promote the reuse of materials
- Asian Paints has also taken steps to promote sustainable procurement practices by engaging with suppliers and ensuring compliance with environmental and social standards
- Asian Paints has implemented a **zero waste to landfill** program that aims to reduce waste generation and promote the reuse of materials
- The company has also taken steps to promote sustainable packaging practices by reducing the use of plastic and increasing the use of recycled materials[1]
- Asian Paints has implemented a **green supply chain** program that aims to reduce the environmental impact of its supply chain by engaging with suppliers and ensuring compliance with environmental and social standards

8.2.Berger Paints

Berger Paints Limited is a multinational paint company headquartered in Kolkata, India. It was founded almost 98 years ago by Lewis Berger and is regarded as the second-best paint company in India, with 16 manufacturing units spread across India, two in Nepal, and one each in Poland and Russia. The company provides a wide range of creative painting solutions with a distribution network comprising more than 50,000 dealers and retailers. In addition to a comprehensive selection of industrial and ornamental paints, the Company provides waterproofing solutions, wood and glass coating, rapid painting services, home, and living services, and other related services. . It has grown so much over the last decade that we now have limitless options to even decide which color we want our walls to be painted. The company has been making strides for the last couple of decades. From humble beginnings in the pre-independence era to be one of the market leaders today, Berger Paints' growth is no overnight success story.

Berger Paints India Limited has a robust environmental policy and is committed to continually improving environmental performance through initiatives taken across its manufacturing units, offices, depots/warehouses with defined Environment Monitoring Plan (EMP). All activities are done with Aspect/Impact studies of the process. Continuous efforts are made to minimize waste and move towards green energy. Risk and Hazard studies are carried out before implementation of any project. Continuous focus on optimization of resource utilization through recycling and reuse. Periodic reviews with management ensure rapid and effective deployment. Energy Management System (EMS) has been implemented which has helped in better monitoring and management of Electrical consumption in different production centers .

Berger Paints India Limited has taken several initiatives towards sustainability. The company has reduced its carbon footprint by adopting all the energy savings measures, coupled with the usage of biofuels which resulted in savings . The company has also implemented an Energy Savings initiative that has reduced the specific energy consumption for paints and powder coatings by approximately 3.26 in FY 21-22 compared to FY 20-21 . The company has also installed a Condensate Recovery System for recovering water from steam . Rainwater conservation is one of the most important alternatives for fresh water consumption at the manufacturing units. Collected water is being reused in operations, gardening, toilets, floor washing, etc.

8.3 DuPont-

DuPont has been around for over 200 years and has made significant contributions to the world through its scientific and technological breakthroughs. The company was founded in 1802 as a manufacturer of gunpowder and has since transformed itself into a modern, diversified chemical company . DuPont has been committed to ensuring the safety and health of its employees, contractors, customers, and communities while protecting the planet. The company has also set ambitious goals to reduce its environmental footprint by reducing greenhouse gas emissions, water usage, and waste generation. DuPont is investing in new technologies to create sustainable solutions for the complex challenges facing our world. The company is focusing on four key impact areas: climate action, enabling a more circular economy, creating products that are safe and sustainable by design, and advancing water stewardship.

According to **2023 Business sustainability report** of DuPont-

DuPont is committed to reducing its environmental footprint and has set a goal to reduce greenhouse gas emissions by 30% by 2030. The company has also

implemented a zero-waste-to-landfill program and has reduced its hazardous waste generation by 50% since 2015
DuPont is working towards creating a more circular economy by using renewable resources, reducing waste, and recycling materials. The company has also set a goal to reduce water usage by 30% by 2030
DuPont is committed to reducing its greenhouse gas emissions by 30% by 2030. The company has also set a goal to reduce its energy consumption by 10% by 2030
DuPont is investing in new technologies to create sustainable solutions for the complex challenges facing our world. The company is focusing on four key impact areas: climate action, enabling a more circular economy, creating products that are safe and sustainable by design, and advancing water stewardship
DuPont has a long-held commitment to ensuring the safety and health of its employees, contractors, customers, and communities while protecting the planet. The company encourages active participation in the communities it works through key partnerships, collaboration with non-profit organizations, skills-based volunteering, and board service

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9. HAZARDS AND RISK ASSESSMENT

9.1 General Assessment

General Assessment Risk assessment involves determining the quantitative or qualitative value of risk in a specific context and the associated threat.

Risk Analysis: This is a systematic approach to describing and calculating risk. Consequence Analysis identifies the harm caused to life and property by an accident, while QRA (Quantitative Risk Analysis) evaluates the following: the frequency of accidents, the risk of fatalities for employees, individual risk (risk of fatalities for the neighboring population), and the acceptability of risk, ensuring it's As Low As Reasonably Practicable (ALARP).

Activities necessitating risk assessment pertain to both onsite and off-site risks due to the occurrence of probable hazard instances.

9.1.1 Risk Analysis Methodologies

Risk assessment often involves synthesizing risk profiles, which represent the probability distribution of annual losses resulting from specific events or activities. These assessments typically entail estimating losses for various sub-classifications within the overall process and aggregating these results into a comprehensive risk profile. The primary methodologies for risk assessment include:

- **Hazard and Operability Study (HAZOP):** HAZOP is a systematic technique for identifying operational hazards in a process. It compiles all possible deviations from normal operating conditions and evaluates their consequences, while also examining the means available to detect and correct these deviations.
- **Fault Tree Analysis (FTA):** FTA is chiefly used for analyzing non-identifiable hazards. First, top events, which are the ultimate incidents to be avoided, are

identified through other techniques like HAZOP. Then, the logical structure of the fault tree displays all combinations of individual failures that could lead to the hazardous event, with the calculation of top event frequency through estimating individual probabilities.

9.2 Hazard Identification

Various types of hazards are associated with the unit's operations, including natural hazards and man-made hazards:

Natural Hazards are events or processes that occur in the environment and are primarily driven by natural forces. They include:

1. Earthquakes: Sudden shaking of the Earth's crust due to tectonic plate movements.
2. Floods: Overflow of water onto normally dry land, often due to heavy rainfall or snowmelt.
3. Hurricanes (Cyclones or Typhoons): Powerful tropical storms characterized by strong winds and heavy rainfall.
4. Tornadoes: Violently rotating columns of air that extend from thunderstorms to the ground.
5. Wildfires: Uncontrolled fires that spread rapidly through vegetation.
6. Volcanic Eruptions: The release of magma, ash, and gases from a volcano.
7. Tsunamis: Large ocean waves generated by underwater disturbances, often earthquakes or volcanic eruptions.

Man-Made Hazards are events or situations that result from human actions or activities and can cause harm to people, property, or the environment. They include:

1. Industrial Accidents: Such as chemical spills, explosions, or nuclear reactor malfunctions.
2. Hazardous Materials Incidents: Release or exposure to dangerous substances, such as toxic chemicals.

3. Transportation Accidents: Including vehicle crashes, train derailments, and plane crashes.
4. Structural Failures: Such as building collapses or dam breaches.
5. Health Pandemics: The widespread outbreak of infectious diseases that can lead to public health crises.

This comprehensive risk assessment approach aims to identify, analyze, and mitigate a wide range of potential hazards for a safer and more secure operational environment.

9.3 Hazards in Paints Industry

a)Accidental Hazards-

Accidents involving descending from elevated areas, such as platforms, ladders, or stairs, and slipping on floors made hazardous by wetness or grease.
Injuries resulting from the collapse of equipment used for jacking, lifting, or hoisting, and incidents where materials fall from lifting machinery.
Toes getting crushed due to the impact of heavy objects falling onto them.
Harm to the eyes caused by flying debris during tasks like grinding, machining, and operating compressed-air equipment.
Injuries occurring when individuals are trapped between objects in motion and stationary items.
Dangers linked to the movement of machinery and equipment's rotating components.
Physical injuries affecting muscles and skeletal structures due to lifting heavy vehicle components, often worsened by awkward postures.
Burns sustained from coming into contact with heated surfaces, exhaust pipes, chemicals, and activities like welding.
The risk of electrocution, which arises due to defects, short circuits, or improper handling of electromechanical tools, and contact with live wires.
The potential for carbon monoxide poisoning due to inadequate ventilation and exposure to vehicle emissions.
Incidents of fires and detonations originating from leaked combustible or explosive materials, or sparked by battery ignition, flame cutting, and welding tasks, among others.
Elevated frequency of road collisions during the process of test driving.
Occurrences of punctures and lacerations attributed to the sharp contours of hand tools, automobile components, and sheet materials.
Explosions occurring due to the rupture of compressed-air conduits or containers.

Instances of tire blowouts.
Accidental events resulting from steam or water pressure cleaners that have been inadequately installed or maintained.

b) **Physical Hazards**:
Exposure to direct and reflected ultraviolet and infrared radiation, particularly during welding tasks.
Exposure to microwave and radiofrequency radiation, commonly seen in heat-sealing processes for panels and upholstery, as well as drying tasks for trim base panels.
Contact with vibrating power-driven hand tools, leading to conditions such as White Finger Syndrome.
Sustaining exposure to excessive noise levels (> 85 dB(A)), especially in tasks like car body work and engine testing.
Facing extreme temperatures, particularly in open garages or during roadwork, which may be worsened by unsafe heating methods, potentially leading to fires and carbon monoxide poisoning.
c) **Chemical Hazards**:
Being exposed to a broad spectrum of industrial chemicals, including heavy metals present in substances like brake fluids, degreasers, lubricants, paints, and solvents, which can result in chronic poisoning.
Developing skin conditions like various types of dermatitis, skin sensitization, eczema, and oil acne due to contact with chemicals such as adhesives, antifreeze, brake fluids, and oils.
Experiencing symptoms like eye irritation, dizziness, nausea, breathing difficulties, and headaches due to interactions with irritating chemicals, their dust, and fumes, such as antiknock agents.

b) **Health Hazards**:
Chronic poisoning risk from lead exposure and its dust and fumes (e.g., radiator repair, battery handling, welding, paint and lubricant use).
Elevated cancer risk due to inhaling diesel exhaust fumes or coming into contact with heavy metals, compounds, asbestos, and benzene.
Higher likelihood of organic brain damage from inhaling diesel exhaust fumes.
Immediate discomfort such as eye and mucous membrane irritation, headaches, breathing issues, and chest tightness from inhaling NOx and respirable particulates.
Gastrointestinal disturbances from accidental or chronic ingestion of adhesives.

c) **Health Risks**:

Ergonomic injuries from lifting and moving heavy loads, resulting in acute musculoskeletal issues (like disk rupture, hernia) due to factors like overexertion and poor posture.
Development of cumulative trauma disorders, including carpal tunnel syndrome, through prolonged repetitive work.
Experience of psychological stress while working under time pressure.

e) **Material Hazards**: Industrial facilities handle a range of materials with inherent hazards related to their chemical properties, temperatures, or pressures. Hazards encompass fire, explosion, and toxic releases. These risks are associated with hazardous chemicals used in industrial operations. These substances, often flammable, explosive, toxic, or corrosive, can be categorized into flammable, unstable, and toxic classes.

Flammable substances necessitate contact with air to release their hazards. In specific conditions, vapors emitted by these substances, when mixed with air, might become explosive, particularly in enclosed spaces. Conversely, if present in substantial quantities, such vapor clouds might also explode in open air.
Unstable substances, whether in liquid or solid form, can undergo violent decomposition, generating blast waves.
Toxic substances are perilous and can inflict significant harm to life upon their release into the atmosphere at specific concentrations.
NFPA (National Fire Protection Association) Codes and Material Safety Data Sheets (MSDS) offer ratings for numerous chemicals based on their flammability, reactivity, and toxicity. Industries are required to maintain records of MSDS, NFPA classification, and hazards related to material exposure.

f) **Mechanical and Physical Hazards**: Personnel may sustain injuries from activities such as cutting, lifting, moving, and operating rotating machinery. Handling and carrying heavy or awkward objects, like bags, can lead to manual handling injuries.

g) **Handling, Storage, and Transportation Hazards**: The project involves the handling of various materials in solid, liquid, and gas forms, necessary for operations. Material transport will occur via the nearest road or rail route. Transportation hazards may arise from vehicular accidents, mechanical transmission component failures, etc. Handling hazards encompass:
Insufficient awareness regarding the hazardous nature of chemicals in use, potentially leading to improper chemical handling.
Failure to implement adequate control measures and use Personal Protective Equipment (PPE).

Utilization of expired or worn-out Personal Protective Equipment (PPE).

Table 7-16: List of Possible Disaster Scenarios

S. No.	Hazard	
1	Fire & Explosions	All types of fires, smoking insulation & auto ignition
2	Major Spillage	Liquid RM like Ropaque, etc., Fuel like HSD or FO
3	Tanker Toppling	Toppling of tanker leading to spillage
4	Fuming	Evolution of Large quantity of fumes/ smoke due to organic fires.
5	Structure collapse	Major collapse of an equipment / building having potential to cause severe loss of life & property
6	Floods	Water logging above 2 feet resulting in machinery / utilities getting submerged in water
7	Earthquake	Natural calamity, having potential to cause severe loss of life & property

Table 9.1 Hazards

9.4 Safety Measures for Hazardous Chemicals in Paint Manufacturing

Reduce the use of hazardous chemicals:

- Consider using less hazardous alternatives to solvent-based paints.
- Label all chemicals with appropriate, internationally recognized hazard symbols.

Store chemicals safely:

- Do not store chemicals with different hazard symbols together.
- Store chemicals in a dedicated, enclosed, secure facility with a roof and a paved/concrete floor.
- Provide adequate ventilation in the storage facility.
- Store chemical tanks in secondary containment.
- Ground the storage facility.
- Display procedures and work instructions for loading and unloading chemicals in English and the local language.

Prevent spills and leaks:

- Install devices to prevent spills and overfills, such as alarms and automatic shut-off devices.
- Maintain and inspect storage units regularly.
- Consider installing groundwater monitoring points on site to check for contamination.

Implement a Solvent/Hazardous Materials Management Plan:

- This plan should monitor and control the use of solvents and hazardous materials on site.

Prepare for emergencies:

- Provide firefighting facilities as per various national and international codes.
- Conduct a hazard identification study, such as a Hazard and Operability Study (HAZOP), to identify and mitigate hazards.
- Have first aid equipment and manpower resources in place to deal with emergencies.
- Carry out regular checks and maintenance on instruments, valves, and flange joints.
- Equip the facility with automatic fire detection and alarm systems, as well as suppression equipment such as fire tenders, extinguishers, and water hydrants.

- Provide fire detection and alarm systems for control rooms, cable galleries, transformer areas, and administrative buildings.
- Install LPG detectors at the LPG station and provide flashback arrestors and grounding and bonding facilities in the LPG pipeline.
- Provide firefighting equipment as per applicable standards and guidelines.
- Consider linking the foam and fire water system.
- Equip the facility with fire suppression equipment that meets internationally recognized technical specifications.
- Provide passive fire protection, such as fire-rated doors and walls, for electrical panel rooms, transformer areas, and chemical storage rooms.
- Provide fire safety training to all employees.

Additional safety measures:

- Protect pipelines against external and internal corrosion.
- Display caution boards in all working places.
- Post no smoking signs and signs prohibiting flames, pilot lights, and electrical gadgets.
- Display emergency contact numbers.
- Ground all electrical equipment.
- Keep electrical equipment free from carbon dust, oil deposits, and grease.
- Lay all electrical cables in cable trays or trenches.
- Use approved insulated tools, rubber mats, shockproof gloves and boots, testers, fuse tongs, discharge rods, safety belts, hand lamps, and wooden or insulated ladders.
- Prevent danger from excess current due to overload or short circuit by providing fuses, circuit breakers, and thermal protection.
- Display do's and don'ts prominently near pipelines and at all workplaces.
- Carry out regular maintenance under the supervision of an authorized person.

9.5 Mitigation Measures:

Mitigation serves as a crucial component in the Environmental Impact Assessment (EIA) process, aimed at safeguarding the environment and the impacted community. This phase, both creative and practical, focuses on identifying the best strategies to prevent, reduce, and address adverse impacts. Successful mitigation relies on the effective translation of these measures into action, requiring timely implementation. Impact management is an integral part of project execution, and it necessitates a well-structured plan with a schedule of agreed actions. Opportunities for mitigation are present throughout the project's life cycle.

Key Considerations for Mitigation Approaches:

- In light of the "Polluter Pay" principle, it is widely recognized that project proponents bear the responsibility of internalizing the complete environmental costs associated with their development proposals. Furthermore, proponents have realized that efficient design and impact management can result in substantial cost savings by implementing cleaner production principles to enhance environmental performance.
- Identification of Impacts: The anticipated adverse environmental and social impacts necessitating mitigation measures should be identified and concisely summarized, with cross-references to the significance and prediction components in the EIA report or other relevant documentation.
- Description of Mitigation Measures: Each mitigation measure should be succinctly described in connection to the associated impact significance and the conditions under which it applies, whether continuous or contingent. These descriptions should be cross-referenced to the project's design and operating procedures, which elaborate on the technical aspects of their implementation.
- Clear Cost and Responsibility Definitions: It is imperative to establish clear definitions of costs and responsibilities for mitigation and monitoring. This includes arrangements for coordination among various authorities responsible for mitigation. The Environmental Management Plan (EMP) can serve as a tool for establishing environmental performance standards for the project site and supply chain. An EMP can be integrated with an Environmental Management System (EMS) for the operational phase of the project.
- Prior to selecting mitigation strategies, it is essential to assess mitigation alternatives for cost-effectiveness, technical feasibility, and socio-political viability. Such mitigation measures could encompass avoiding sensitive areas, adjusting work schedules to minimize disturbances, utilizing engineered structures like berms and noise attenuation barriers, deploying pollution control devices such as scrubbers and electrostatic precipitators, or implementing changes in fuel feed, manufacturing processes, technology use, and waste management practices.

10.SUMMARY

The e-guide, "Best Practices and Environmental Compliance in the Paint Industry," is a comprehensive and informative resource that covers every facet of the paint industry in India. It begins with an in-depth look at the categorization of paints and provides a comprehensive overview of the industry, including the raw materials used and the production processes involved. It places a strong emphasis on environmental concerns, discussing major pollutants and presenting mitigation measures to tackle air and water pollution. The guide further addresses waste minimization techniques, with a focus on reducing wastewater and VOC emissions.

In the regulatory domain, the guide outlines clearance conditions for establishing paint industry operations and discusses emissions, effluent, and service water standards. It also introduces e-guidelines for managing solvent losses, highlighting the industry's digital compliance initiatives. The e-guide provides a unique perspective on advanced planting techniques for environmental improvement, showcasing plant species recommended for the paint industry.

Moreover, it explores the latest technological solutions and best practices to enhance environmental sustainability. Success stories from leading paint manufacturers like Asian Paints, Berger Paints, and DuPont serve as inspiring examples of environmental excellence within the industry. The guide also takes a deep dive into hazard and risk assessment methodologies, offering insights into hazard identification, safety measures, and risk mitigation practices. In sum, this e-guide is an indispensable reference for anyone in the paint industry, offering a comprehensive toolkit to ensure environmental compliance, reduce waste, and improve sustainability.