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TITLE

"Industrial Hygiene in Practice: A Study on the Integration of Exposure Monitoring into Industrial Hygiene Practices in Food and Port Industries"

Tutor: Prof. Enrico Maria Staderini

Candidate: Sankara Bhavani Budi

Coordinator: Prof. Gianluca Verona Rinati

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DECLARATION

I hereby declare that the results of the study incorporated in the thesis entitled **"Industrial Hygiene in Practice: A Study on the Integration of Exposure Monitoring into Industrial Hygiene Practices in Food and Port Industries",** is original and no part of this thesis has been submitted for the award of any other degree prior to this date. This work has been carried out under the supervision of Prof. Enrico Maria Staderini, co supervisor (Late) Prof. P.S. Prasad Dandamudi and Ph.D. Coordinator, Prof. Gianluca Verona Rinati, Department of Industrial Engineering, University of Rome "Tor Vergata" Italy.

Sankara Bhavani Budi.
Matricola: 0283255
AY: 2019-2023

ABSTRACT

This study embarks on an in-depth investigation into the industrial hygiene practices in two critical sectors of the Indian economy: the food industry, with a specific focus on the Horlicks production facility, and the maritime sector, concentrating on Kakinada Sea Ports Limited. The primary aim is to assess the current state of occupational health and safety measures in these industries and identify enhancement opportunities, thereby contributing to improved worker safety and health. The research employs a mixed-method approach, integrating qualitative and quantitative data collection methods, which include surveys, interviews, observational studies, and exposure monitoring devices.

In the food sector, the study will specifically scrutinize the manufacturing processes of Horlicks, a widely consumed health beverage, examining the handling of raw materials, production process, and end-product safety measures. The study aims to evaluate the effectiveness of hygiene practices in mitigating occupational hazards and ensuring product safety. In contrast, the focus at Kakinada Sea Ports Limited will be on the occupational health risks associated with port activities, including cargo handling, exposure to potentially hazardous materials, and the operation of heavy machinery.

This study yields valuable insights into the efficacy of current industrial hygiene practices, highlighting areas of excellence and pinpointing gaps that need addressing. The goal is to provide actionable recommendations to enhance worker safety and health standards, thereby contributing to the broader objective of fostering sustainable and responsible industrial practices in Industries. The findings of this study hold the potential to inform policy decisions, influence industry standards, and eventually improve the quality of life for workers in these industries.

1. INTRODUCTION

The field of industrial hygiene stands at the forefront of occupational health and safety, serving as a vital shield in safeguarding the workforce against a myriad of occupational hazards. This thesis, titled "Safeguarding the Workforce: The Critical Role of Industrial Hygiene in Industry with a Focus on Exposure Monitoring," aims to delve into the complexities and nuances of industrial hygiene with a particular emphasis on the aspect of exposure monitoring. This research aims to bridge gaps in current knowledge, propose innovative solutions, and reinforce the significance of industrial hygiene in creating healthier, safer workplace environments.

1.1. Background and Rationale

The rationale for this study stems from the increasing awareness and concern regarding occupational health risks in various industries. As global industrialization accelerates, the potential for exposure to harmful agents like chemical, biological, and physical intensifies. This escalation calls for a sophisticated and comprehensive approach to monitoring exposures and mitigating these risks. The role of industrial hygiene, therefore, becomes paramount in ensuring the well-being of the workforce and, by extension, the productivity and sustainability of industries themselves.

1.2. Research Aims and Objectives

The primary aim of this research is to critically examine and enhance the methodologies and practices of exposure monitoring within the field of industrial hygiene. To achieve this, the research is structured around several key objectives:

- To carry out a thorough review of existing literature on industrial hygiene with a focus on exposure monitoring, thereby establishing a theoretical framework for the study.
- To analyse current practices and trends in **exposure monitoring** across various industries, identifying strengths and areas needing improvement.
- To investigate the impacts of exposure to different hazardous agents on workers' health, considering both short-term and long-term effects.
- To explore technological advancements and innovative approaches in exposure assessment and monitoring.
- To develop recommendations for best practices in exposure monitoring that can be implemented across diverse industrial settings.

This research adopts a mixed-methods approach, integrating both qualitative and quantitative data. The methodology includes a comprehensive literature review, case studies, field observations, exposure monitoring using various devices and equipment, and statistical analysis. Surveys and interviews with industry professionals, health and safety experts, and workers will also be conducted to acquire diverse perspectives on the current state of industrial hygiene practices.

1.3. Significance of the Study

The significance of this research lies in its potential to influence policy, enhance safety protocols and industrial hygiene training, and ultimately contribute to improving occupational health standards. By providing a deeper understanding of exposure risks and monitoring techniques, this study aims to advocate for more effective health and safety measures in workplaces, thereby reducing the incidence of occupational diseases and injuries.

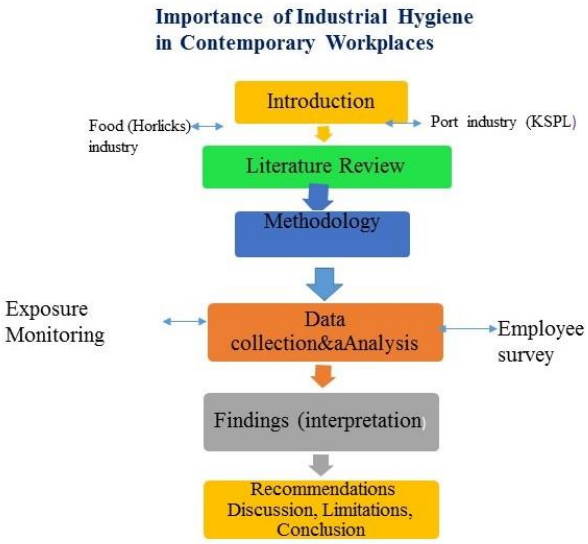
1.4. Structure of the Thesis

This thesis will be organized into several chapters, each addressing different facets of the research topic. Following this introduction, the subsequent chapters will cover the theoretical background, methodology, data analysis, findings, and conclusions, along with recommendations for future research and practice in the field of industrial hygiene.

1.5. Conclusion

This introductory chapter has established the groundwork for a comprehensive study into the critical role of industrial hygiene in modern industries. The subsequent chapters will provide a more through exploration of the research objectives, offering a detailed analysis and discussion of the findings.

1.6. Study Outline



(Figure.1. Study Outline)

2. LITERATURE STUDY

2.1. The Historical Evolution of Industrial Hygiene

Industrial hygiene is the discipline of anticipating, recognizing, evaluating, and controlling workplace hazards to protect workers' health and well-being. Because of advances in science and technology, as well as the changing nature of work environments, industrial hygiene has evolved significantly over time.

2.1.1. Industrial Revolution and Early Concerns (18th to 19th century):

The beginning of the Industrial Revolution significantly impacted the historical evolution of Industrial Hygiene during the 18th and 19th centuries. This period witnessed a substantial change from traditional practices toward mechanized and industrialized ones.

Workers were exposed to new occupational hazards as factories and manufacturing processes increased rapidly, such as unsafe machinery, toxic chemicals, and unsafe working conditions. Early concerns about worker safety and health emerged during this period, driven in part by the pioneering work of people like Edwin Chadwick, who investigated industrial workers' poor working conditions and played crucial roles in raising awareness about occupational health hazards.

The Factory Act of 1833 in the United Kingdom and other labour rules and regulations began to address some of these concerns, bringing in formal efforts to protect worker health and safety in industrial working conditions. These early advances created the way for the field of Industrial Hygiene to develop and expand its scope in response to the changing industrial environment.

2.1.2. Emergence of Occupational Health (Late 19th to Early 20th Century):

The Industrial Revolution brought a surge in occupational diseases due to exposure to chemicals, dust, and poor working conditions. This led to a significant turning point in the historical evolution of industrial hygiene and the emergence of occupational health as an independent discipline. The Industrial Revolution was in full force, resulting in rapid urbanization and the expansion of factories and industries. As a result, workers faced hazardous conditions, long working hours, and exposure to hazardous substances without adequate personal protection. These developments paved the way for the development of occupational health and safety regulations and the growth of organizations dedicated to safeguarding the health and well-being of workers, ultimately shaping the modern field of industrial hygiene and occupational health (Krieger, 2008; Markowitz & Rosner, 2002).

2.1.3. Formation of Occupational Safety and Health Organizations (20th century)

The development of various Occupational Safety and Health Organizations, both internationally and in India, reflected the historical growth of Industrial Hygiene in the twentieth century, indicating the growing recognition of the significance of worker safety. Internationally, the International Labour Organization (ILO), founded in 1919, has played an essential part in establishing worldwide workplace safety standards and promoting worker protection. Established the Occupational Safety and Health Administration (OSHA) in the United States in 1970 was a historic turning point in the evolution of occupational safety legislation. The American Conference of Governmental Industrial Hygienists (ACGIH)

developed as a prominent organization in the United States in 1938, dedicated to promoting and enhancing industrial hygiene by developing guidelines, standards, and education. The Factory Act of 1948 in India was a significant turning point in the country's occupational health and safety path, highlighting the need for workplace health and safety procedures. Furthermore, the formation of the National Safety Council aided in the spread of safe practices across numerous various industries. These organizations have played an effective role in shaping and promoting industrial hygiene practices.

2.1.4. Focus on Industrial Hygiene Principles (Mid-20th Century):

The field of industrial hygiene witnessed significant evolution in the twentieth century due to an increasing recognition of the health and safety hazards and risks posed by industrial processes. The principles of industrial hygiene advanced alongside technological and scientific progress. Early in the century, efforts focused on mitigating acute risks such as toxic chemicals and dust exposure. Later, industrial hygiene gained prominence as efforts were made to protect workers from various occupational hazards associated with workplace activities and conditions. In the mid-twentieth century, essential principles such as exposure assessment, risk assessment, and the hierarchy of controls were developed, emphasizing the significance of prevention through engineering controls, administrative measures, and personal protective equipment. The realization of long-term health impacts, such as occupational cancers and other disorders and ergonomic-related injuries, in the later part of the century led to the adoption of broader health protection standards. The field also witnessed the emergence of regulatory authorities and standards, highlighting the significance of industrial hygiene principles in safeguarding worker health and well-being.

2.1.5. Globalization and Technological Advances (Late-20th Century):

The late 20th century marked a significant phase in the evolution of industrial hygiene, with globalization and technological advances playing a significant part in establishing occupational safety standards. During this time, the United States took a significant step further by establishing the Occupational Safety and Health Administration (OSHA) in 1970, which introduced Permissible Exposure Limits (PELs) to control hazardous substance exposures in the workplace. At the same time, the American Conference of Governmental Industrial Hygienists (ACGIH) developed Threshold Limit Values (TLVs) and Short-Term Exposure Limits (STELs) as more conservative guidelines to protect workers. Meanwhile, the National Institute for Occupational Safety and Health (NIOSH) established the Immediately Dangerous to Life and Health (IDLH) values, representing exposure levels that may result in potentially fatal consequences. These advancements increased worker safety and laid the foundation for international occupational health standards.

2.2. Evolution of Industrial Hygiene Regulations and Standards

Developing industrial hygiene rules, regulations, and standards has been crucial in ensuring worker safety and health in various industries. These rules, regulations, and standards emerged over time due to changing workplace conditions, scientific advancements, and a growing understanding of risks associated with industrial processes.

Early Industrialization (Late 19th Century):

- Conditions: The Industrial Revolution led to widespread workplace hazards.
- Response: Initially, there were few regulations. The focus was on productivity rather than worker safety.

Early Regulations (Early to Mid-20th Century):

- Conditions: Industrialization continued, and workplace injuries and diseases were prevalent.
- Response: Governments began to enact basic safety regulations. These often focused on specific industries and hazards.

Post-World War II (1940s-1960s):

- Conditions: Increased industrialization after World War II intensified workplace hazards.
- Response: Governments recognized the need for comprehensive regulations. Occupational safety and health agencies were established in several countries.

Creation of Occupational Safety and Health Administration (OSHA) in the United States (1970):

- Conditions: The U.S. experienced a rise in workplace accidents and diseases.
- Response: OSHA was created to develop comprehensive safety and health standards for various industries.

International Standards (1970s Onward):

- Conditions: Globalization increased, leading to a need for harmonized standards.
- Response: Organizations such as the International Labour Organization (ILO) and the World Health Organization (WHO) contributed to developing international standards.

Focus on Specific Hazards (1980s-1990s):

- Conditions: Increased understanding of specific workplace hazards (e.g., asbestos, lead).
- Response: Regulations became more specialized, targeting specific substances and processes.

Shift to Risk-Based Approaches (Late 20th Century Onward):

- Conditions: Advances in risk assessment and management.
- Response: Regulations started incorporating risk-based approaches, considering the likelihood and severity of hazards.

Technological Advances (21st Century):

- Conditions: Rapid technological changes in industries.
- Response: Emphasis on incorporating technology for monitoring and managing workplace hazards. Data analytics, sensors, and artificial intelligence became more prevalent.

Global Harmonization and Collaboration (21st Century):

- Conditions: Increased global interdependence of economies.
- Response: Efforts were made to harmonize regulations globally to ensure consistency in protecting workers' health and safety.

Emphasis on Worker Involvement and Well-being (Present):

- Conditions: Recognition of the importance of worker participation and well-being.
- Response: Modern regulations increasingly focus on worker engagement, mental health, and well-being.

Adaptation to Emerging Industries (Ongoing):

- Conditions: Emergence of new industries (e.g., biotechnology, nanotechnology).
- Response: Ongoing efforts to adapt regulations to address new and emerging workplace hazards.

Sustainability and Green Practices (Ongoing):

- Conditions: Growing emphasis on sustainability and environmentally friendly practices.
- Response: Inclusion of environmental aspects in industrial hygiene regulations.

2.3. The current state of Industrial Hygiene

Technological Advancements:

- Real-Time Monitoring: Increased use of real-time monitoring technologies for exposure assessment.
- Data Analytics: Growing integration of data analytics for risk assessment and trend analysis.
- IoT and Sensors: The Internet of Things (IoT) and sensor technologies significantly monitor workplace conditions.

Emerging Hazards:

- Nanotechnology: Continued focus on understanding and managing risks associated with nanomaterials.
- Biotechnology: Recognition of potential hazards in biotechnological processes.
- Psychosocial Factors: Increasing attention to the psychological and social aspects of the work environment.

Globalization:

- Supply Chain Complexity: Recognition of the challenges associated with global supply chains, including diverse regulatory environments and cultural considerations.
- Global Standards: Efforts towards global harmonization of occupational health and safety standards.

Integration with Other Disciplines:

- Occupational Health: Closer integration with occupational health programs.
- Environmental Health: Collaboration with environmental health initiatives for a holistic approach.
- Human Factors and Ergonomics: Understanding the interplay of human factors in workplace safety.

Regulatory Landscape:

- Updates to Standards: Periodic updates to relevant authorities' industrial hygiene standards and regulations.
- Shift to Risk-Based Approaches: A shift toward risk-based approaches to occupational health and safety.

Remote Work Considerations:

- Pandemic Impacts: The COVID-19 pandemic has brought attention to the challenges of remote work and the need for adaptable safety measures.
- Mental Health Focus: Increased awareness of mental health issues and their impact on well-being.

Training and Education:

- Continuous Learning: Emphasis on continuous education and training for industrial hygiene professionals.
- Online Resources: Increased availability of online resources for training and professional development.

Sustainability and Green Practices:

- Environmental Sustainability: Growing consideration of environmental sustainability in occupational health and safety practices.

Worker Involvement:

- Participatory Approaches: Recognition of the importance of involving workers in identifying and addressing workplace hazards.

Corporate Social Responsibility (CSR):

- Corporate Wellness Programs: Companies are increasingly investing in employee wellness programs.
- CSR Initiatives: Incorporation of industrial hygiene and safety into corporate social responsibility (CSR) initiatives.

Research and Development:

- Innovative Solutions: Ongoing research for innovative solutions in exposure monitoring, control measures, and protective equipment.

Regulatory Compliance Technology:

- Digital Solutions: Use digital tools to manage and ensure compliance with industrial hygiene regulations.

2.4. Challenges faced by Industries while implementing Industrial hygiene

Regulatory Compliance:
Complex Regulatory Environment: Negotiating through a complex web of regulations and compliance standards can be challenging for industries. Ensuring adherence to diverse regulatory requirements poses a significant hurdle.
Limited Resources:
Financial Constraints: Many businesses, especially in the small and medium-sized enterprise (SME) sector, may face financial constraints, limiting their ability to invest in state-of-the-art industrial hygiene measures.
Awareness and Training:
Lack of Awareness: Limited awareness among workers and management regarding the importance of industrial hygiene and the potential health risks associated with poor practices can hinder implementation.
Infrastructure Challenges:
Outdated Infrastructure: Aging infrastructure in ports and food processing units may pose challenges in retrofitting and implementing modern industrial hygiene technologies and practices.
Cultural and Behavioural Factors:
Resistance to Change: Resistance to adopting new practices and technologies due to traditional work cultures and established routines can impede the implementation of industrial hygiene measures.
High Turnover and Informal Labour:
High Turnover Rates: Frequent turnover of labour in industries may hinder the continuity and effectiveness of industrial hygiene training programs.
Informal Labour Practices: Informal labour practices prevalent in some sectors can make it challenging to enforce and monitor industrial hygiene standards.
Supply Chain Complexity:
Fragmented Supply Chains: The complexity and fragmentation of supply chains in the food and port industries can make it challenging to consistently adhere to industrial hygiene standards.
Technological Readiness:
Limited Adoption of Technology: Some industries may need help with the adoption of advanced technologies for monitoring and controlling hygiene hazards due to a lack of technological readiness.

Inadequate Data and Monitoring:
Data Collection Challenges: The need for comprehensive data on occupational health and safety incidents may impede the development of effective industrial hygiene strategies.
Monitoring Gaps: Monitoring systems can help real-time assessment of workplace hazards.
Emergency Preparedness:
Inadequate Emergency Response Plans: The need for robust emergency response plans and drills may compromise the ability to handle accidents or industrial incidents effectively.
Environmental Considerations:
Waste Management Challenges: Proper management of industrial waste, especially in the food industry, can pose environmental challenges and impact overall hygiene.
Globalization and Trade Standards:
Meeting International Standards: Adhering to international trade standards and ensuring that products meet global hygiene standards can be a significant challenge.
Climate-Related Challenges:
Climate Impact on Ports: Climate change-related events, such as extreme weather conditions and rise of sea levels, may pose challenges in maintaining hygiene standards in port facilities

2.5. Common hazards and risk factors in Port Industry

Manual Handling and Ergonomics:
Risk Factors:

- Heavy lifting and carrying of cargo.
- Awkward postures during manual handling.

Hazards:

- Musculoskeletal disorders (MSDs) due to repetitive tasks.
- Back injuries, strains, and sprains.

Cargo Handling Equipment:
Risk Factors:

- Operation of different types of cranes, forklifts, and other heavy machinery.

Hazards:

- Collisions, tip-overs, and falls from equipment.
- Entanglement and crush injuries.

Falls from Heights:
Risk Factors:

- Working on elevated platforms, ship decks, or stacks of cargo.

Hazards:

- Falls from heights lead to severe injuries or fatalities.
- Slips and trips on elevated surfaces.

Confined Spaces:
Risk Factors:

- Enclosed spaces in ships, cargo holds, or storage areas.

Hazards:

- Inadequate ventilation leads to the accumulation of toxic gases.
- Entrapment, asphyxiation, or other confined space-related incidents.

Exposure to Hazardous Substances:
Risk Factors:
- Handling and transport of hazardous materials, including chemicals and fuels.

Hazards:
- Exposure to toxic substances leads to respiratory issues or chemical burns.
- Fire and explosion risks.

Noise and Vibration:
Risk Factors:
- Operation of heavy machinery, equipment, and ship engines.

Hazards:
- Long-term exposure to excessive noise levels might result in auditory impairment.
- Whole-body vibration leads to musculoskeletal problems.

Weather Conditions:
Risk Factors:
- Exposure to adverse weather conditions, including storms and extreme temperatures.

Hazards:
- Slippery surfaces lead to slips and falls.
- Hypothermia or heat-related illnesses.

Ship Operations:
Risk Factors:
- Working on moving vessels during mooring and unmooring.

Hazards:
- Crush injuries during mooring operations.
- Risks of falling into the water.

Electrical Hazards:
Risk Factors:
- Use of electrical equipment and machinery.

Hazards:
- Electric shocks and electrocution.
- Fire hazards due to electrical malfunctions.

Vehicle Traffic:
Risk Factors:
- Movement of trucks, forklifts, and other vehicles within the port.

Hazards:
- Collisions between vehicles and pedestrians.
- Struck-by incidents.

Biological Hazards:
Risk Factors:
- Handling of biohazardous materials, waste, or contaminated cargo.

Hazards:
- Infections or diseases from exposure to biological agents.
- Risks associated with pests and vectors.

Fatigue and Long Working Hours:
Risk Factors:
- Long shifts and irregular working hours.

Hazards:
- Increased risk of accidents due to impaired concentration and reaction times.
- Fatigue-related health issues.

Communication Challenges:
Risk Factors:
- Multinational workforce with language barriers.

Hazards:
- Miscommunication leads to errors and accidents.
- Ineffective emergency response due to language issues.

2.6. Common hazards and risk factors in the Food Industry

Raw Material Handling and Storage:
Hazard: Contamination
Risk Factors: Improper storage leads to spoilage or contamination.
Mishandling of raw materials.
Preventive Measures: Adequate storage conditions and separation of raw materials.
Proper training for handling and inspection.

Processing and Manufacturing:
Hazard: Machinery and Equipment
Risk Factors: Operation of processing machinery.
Inadequate machine guarding.
Preventive Measures: Regular equipment maintenance.
Installation of safety guards and emergency shut-off systems.

Heat and Thermal Processing:
Hazard: Burns and Scalds
Risk Factors: Exposure to hot surfaces, steam, or boiling liquids.
Preventive Measures: Use of personal protective equipment (PPE).
Implementation of safe work practices.

Cleaning and Sanitization:
Hazard: Chemical Exposure
Risk Factors: Handling and use of cleaning chemicals.
Inadequate personal protective equipment.
Preventive Measures: Proper training on chemical handling.
Use of appropriate PPE, such as gloves and goggles.

Packaging:
Hazard: Machinery and Repetitive Motion

Risk Factors: Operation of packaging machinery.
Repetitive motions lead to musculoskeletal disorders.
Preventive Measures: Ergonomic design of workstations.
Rotation of tasks to minimize repetitive motions.

Material Handling and Transportation:
Hazard: Manual Handling and Forklift Operations
Risk Factors: Lifting and carrying heavy loads.
Forklift operations.
Preventive Measures: Manual handling training.
Proper forklift training and maintenance.

Storage and Warehousing:
Hazard: Falling Objects
Risk Factors: Poorly stacked items lead to falling objects.
Preventive Measures: Proper storage procedures.
Use of safety nets and barriers.

Electrical Hazards:
Hazard: Electric Shocks and Fires
Risk Factors: Use of electrical equipment.
Damaged electrical cords.
Preventive Measures: Regular electrical inspections.
Proper training on electrical safety.

Biological Hazards:
Hazard: Microbial Contamination
Risk Factors: Improper handling of raw materials and finished products.
Need for adequate sanitation.
Preventive Measures: Strict hygiene practices.
Regular sanitation and cleaning protocols.

Emergency Preparedness:
Hazard: Lack of Emergency Response Planning
Risk Factors: Lack of preparedness for fires, spills, or other emergencies.
Preventive Measures: Development and regular practice of emergency response plans.
Adequate training in emergency procedures.

Noise and Vibration: Hazard: Hearing Damage and Vibration-Related Disorders
Risk Factors: Exposure to loud machinery and equipment.
Use of vibrating tools.
Preventive Measures: Hearing protection.
Use of anti-vibration tools.

Vehicle Traffic:
Hazard: Pedestrian-Vehicle Collisions
Risk Factors: Movement of forklifts, pallet jacks, or other vehicles.
Lack of pedestrian safety measures.
Preventive Measures: Designated pedestrian walkways.
Training for both vehicle operators and pedestrians.

Chemical Hazards:
Hazard: Exposure to Food Additives or Processing Chemicals
Risk Factors: Contact with food processing chemicals.
Inhalation or skin exposure.
Preventive Measures: Proper handling procedures.
Adequate ventilation in processing areas.

2.7. The significance of the Food and Port industries in India

India's Food and Port industries play a crucial role in the country's economic development and are vital components of its trade and commerce. Here is an exploration of the significance of these industries

2.7.1. Food Industry:

Employment Generation: The food industry is a significant employer in India, providing jobs to millions across the agricultural, processing, and distribution sectors.

Agricultural Backbone: India's agriculture sector is closely linked to the food industry, with farmers producing diverse crops and raw materials for food processing.

Economic Contribution: The food industry contributes significantly to India's GDP, making it a key driver of economic growth.

Export Opportunities: With a wide variety of spices, grains, and processed foods, the Indian food industry has substantial export potential, contributing to foreign exchange earnings.

Cultural Heritage: The food industry reflects India's diverse cultural heritage, showcasing various regional cuisines and traditional food products.

Supply Chain Integration: The industry has facilitated the development of an integrated supply chain, connecting farmers, processors, distributors, and retailers.

Food Security: The food industry is critical in ensuring food security by providing a stable supply of essential commodities.

Innovation and Modernization: There is a growing emphasis on innovation and the adoption of modern processing techniques, contributing to the growth of the sector.

2.7.2. Port Industry:

Gateway to International Trade: Indian ports are vital gateways for international trade, facilitating the import and export of goods.

Trade and Commerce Hub: Ports are central to India's trade and commerce activities, connecting the country to global markets.

Employment Opportunities: Port activities generate employment, from dockworkers and logistics personnel to administrative staff.

Infrastructure Development: The development of ports necessitates infrastructure projects, contributing to overall economic development.
Trade Balance: Efficient port operations influence the trade balance, impacting the cost and speed of imports and exports.

Connectivity: Ports enhance connectivity, serving as transportation hubs that link various regions within India and connect the country to the global supply chain.

Logistics and Transportation: Ports play a crucial role in the logistics and transportation network, supporting industries by ensuring the smooth movement of goods.

Strategic Importance: Ports are essential for national security and defence, as they influence the country's maritime capabilities.

2.7.3. Interconnection of Food and Port Industries

Export Facilitation: Ports are pivotal in facilitating the export of agricultural and processed food products, supporting the global reach of the Indian food industry.

Import of Raw Materials: Ports enable the import of raw materials crucial for the food industry, contributing to the production of a wide range of food products.

Supply Chain Efficiency: Efficient port operations enhance the overall supply chain efficiency for the food industry, ensuring timely delivery of goods.

Market Access: Ports provide market access by connecting Indian food producers to international markets, facilitating trade agreements and collaborations.

2.8. Importance of Industrial Hygiene in Port and Food industries

Industrial hygiene is crucial in the port and food industries to safeguard workers' health and well-being, ensure product safety, and meet legal requirements.
Effective industrial hygiene practices contribute to a safer workplace, which promotes worker morale. This corresponds to a hygienic work environment free of health and safety hazards and risks in the food industry and a lower chance of accidents, injuries, and exposures in the port facility. Higher morale often leads to increased productivity and lower absenteeism.

Port industry:
Ports are bustling locations where materials are loaded and unloaded from ships. The presence of heavy machinery, vehicles, and potentially hazardous materials such as chemicals, toxic fumes, and dust necessitates stringent industrial hygiene practices. It is essential to safeguard workers from occupational injuries, accidents, and diseases by maintaining appropriate air quality, managing noise levels, and reducing potential exposures to harmful substances.

Food industry:
Industrial hygiene plays a crucial role in ensuring food safety and quality in the food industry. This involves maintaining a clean and hygienic environment to prevent food contamination from biological, chemical, or physical hazards and risks. Proper sanitation, pest control, and waste management are essential practices. Following industrial hygiene protocols, such as stringent sanitation procedures and employee training, ensures the quality and safety of food products and protects the workforce's health. Overall, industrial hygiene is essential in food industries to promote a safe and healthy working environment, protect workers, and preserve product integrity.

2.9. Analysis of Specific Standards Applicable to the Food (Horlicks) Industry – Based on Literature and Factory Manuals.

Analysing the application of Occupational Safety and Health (OSH) and American Conference of Governmental Industrial Hygienists (ACGIH) standards in the food industry, focusing on the specific context of Horlicks production is crucial. As a widely consumed health drink, Horlicks demands stringent adherence to safety and health standards to ensure worker safety and product quality.

OSH Standards in the Food Industry
Hazard Analysis and Critical Control Points (HACCP):

- Importance: Essential for identifying and controlling potential hazards in food production.
- Application in Horlicks Production: Analysis of stages where physical, chemical, or biological hazards could impact product safety.

Personal Protective Equipment (PPE):

- Regulation: Mandate the use of appropriate PPE to protect against industry-specific hazards.
- Implementation for Horlicks: Specialized attire to prevent contamination and protect workers from dust or allergens during production.

Ergonomic Standards:

- Objective: To prevent musculoskeletal disorders, a common issue in manufacturing jobs.
- Horlicks Production Context: Ergonomic assessment of equipment and processes to minimize strain on workers.

ACGIH Standards
Industrial Ventilation:

- Standard: ACGIH provides guidelines on proper ventilation to control airborne contaminants.
- Relevance in Horlicks Production: Ensuring adequate ventilation in production areas to control flour dust and maintain air quality.

Threshold Limit Values (TLVs):

- Purpose: TLVs guide exposure limits to chemical substances and physical agents.
- Application for Horlicks: Monitoring and controlling exposure to any chemicals used in production.

Biological Exposure Indices (BEIs):

- Definition: BEIs are guidelines for assessing workers' exposure to biological agents.
- Horlicks Production Relevance: Ensuring that microbiological standards are maintained, especially in quality control laboratories.

2.9.1. Compliance and Challenges by Horlicks Factory in Adhering to Various Safety and Health Standards

Compliance:

- Regular inspections and audits to ensure compliance with OSH and ACGIH standards.
- Training programs for staff on safety standards and protocols.

Challenges:

- Continuous Monitoring: Maintaining consistent monitoring of environmental and safety standards.
- Upgradation of Equipment: Ensuring that production equipment is regularly updated to meet safety standards.

Innovative Practices:

- Implementation of advanced safety management systems.
- Incorporation of technology in monitoring and maintaining safety standards.

2.9.2. Best Practices Implemented at Horlicks factory for Maintaining High Standards of Safety and Health

Robust Safety Management Systems

Implementing a safety management system that identifies, assesses, and manages workplace risks.

Regular safety audits and risk assessments to ensure continuous improvement.

Strict Adherence to Good Manufacturing Practices (GMP)

- Ensuring that all processes comply with GMP to guarantee product quality and safety.
- Regular GMP training for all employees to keep them updated on best practices and standards.

Comprehensive Employee Training

- Regular training sessions on health and safety, emergency response, and proper equipment usage.
- Specialized training for handling specific materials or operating certain machinery.

Personal Protective Equipment (PPE)

- Providing appropriate PPE such as gloves, safety glasses, hairnets, and ear protection, and ensuring proper use.
- Regular inspections and maintenance of PPE.

Ergonomic Workplace Design

- Designing workstations to minimize physical strain and reduce the risk of musculoskeletal disorders.
- Implementing automation where possible to reduce manual handling risks.

Effective Communication

- Clear and regular communication channels for discussing safety concerns and suggestions.
- Visible signage and instructions for safety protocols throughout the facility.

Emergency Preparedness and Response

- Well-defined emergency response plans for various scenarios like fire, chemical spills, or medical emergencies.
- Regular drills and training to ensure preparedness.

Health and Wellness Programs

- Programs to promote overall employee health, including medical check-ups, stress management, and fitness activities.
- Access to healthcare and counselling services.

Hygiene and Sanitation

- Strict hygiene protocols, especially in production areas, to prevent contamination.
- Regular cleaning and sanitation schedules for equipment and facilities.

Quality Control and Process Monitoring

- Stringent quality control checks at different stages of the production process.
- Continuous monitoring and control of critical process parameters.

Compliance with Legal and Regulatory Standards

- Ensuring all practices comply with local, national, and international regulations and standards.
- Keeping abreast of changes in legislation and updating practices accordingly.

Use of Technology for Safety Enhancements

- Implementing advanced technology for monitoring safety and health standards.
- Data-driven approaches to predict and prevent potential hazards.

2.10. Analysis of Specific Standards Applicable to the Port (Kakinada Sea Ports Limited -KSPL) Industry - Based on Literature and KSPL Manuals.

Indian Regulatory Framework:

- The Major Port Trusts Act: Analysis of how this Act governs safety and health in major Indian ports.
- Dock Workers (Safety, Health, and Welfare) Regulations: Specific regulations for dock worker safety and their applicability to KSPL.
- Indian Ports Act: Discussion on the provisions of this Act related to port safety and environmental compliance.

Occupational Safety and Health (OSH) Standards in KSPL:

- Safety Management: Evaluation of safety management practices, including risk assessment and mitigation strategies.
- Worker Health Programs: Assessment of health monitoring and medical facilities available to KSPL workers.
- Emergency Response Protocols: Analysis of emergency preparedness and response mechanisms at KSPL.

Environmental and Hazardous Material Handling Standards:

- Waste Management and Pollution Control: Review of KSPL's compliance with environmental waste management and pollution control standards.
- Handling of Hazardous Materials: Standards and practices for the safe handling, storage and transportation of hazardous materials in KSPL.

Training and Awareness Programs:

- Worker Training: Examination of training programs for KSPL employees in safety practices, emergency procedures, and handling equipment.
- Awareness Initiatives: Assessment of awareness campaigns and regular drills conducted for safety and emergency preparedness.

2.10.1. Compliance Challenges Faced by KSPL in Adhering to Various Safety and Health Standards

Complex Regulatory Environment:

- Multiplicity of Regulations: KSPL navigates a complex web of national and international regulations, which can be challenging to harmonize and implement consistently.
- Rapidly Changing Standards: Keeping up with evolving safety and health standards, especially those set by international bodies, requires constant vigilance and adaptability.

Diverse Operational Risks:

- Varied Nature of Cargo: Handling diverse cargo types, each with its own set of hazards, complicates the implementation of uniform safety procedures.
- Environmental Risks: The port's location may pose unique environmental challenges, such as monsoon weather or high humidity, impacting safety protocols.

Human Factors and Workforce Challenges:

- Training and Awareness: Ensuring that all employees, including temporary and contract workers, are adequately trained and aware of safety protocols.
- Cultural and Language Barriers: With a diverse workforce, effectively communicating safety standards and procedures can be a challenge.

Technological and Infrastructure Limitations:

- Aging Infrastructure: Upgrading older infrastructure to meet safety standards can be resource-intensive.
- Technology Integration: Adopting to advanced safety technologies, such as automated monitoring systems, requires significant investment and training.

Economic and Operational Pressures:

- Cost Constraints: Balancing the financial investments required for compliance against operational costs.
- Operational Efficiency: Implementing stringent safety measures can sometimes be perceived as slowing down operational processes

2.10.2. Best Practices Implemented at KSPL for Maintaining High Standards of Safety and Health

Comprehensive Safety Management Systems:

- Risk Assessment and Mitigation: Regular risk assessments and developing targeted mitigation strategies for identified hazards.
- Integrated Safety Management: Adopting an integrated approach that encompasses all aspects of port operations.

Training and Capacity Building:

- Regular Training Programs: Conducting regular and comprehensive training sessions for all employee levels, focusing on general safety and job-specific risks.
- Empowering Employees: Encouraging a culture where employees are empowered to identify and report safety concerns.

Health and Wellness Initiatives:

- Regular Health Check-ups: Instituting mandatory health screenings and medical check-ups for employees with the collaboration of APOLLO hospitals.
- Mental Health and Well-being Programs: Addressing not only physical but also mental health aspects of the workforce.

Emergency Preparedness and Response:

- Regular Drills and Simulations: Conducting frequent emergency response drills to ensure preparedness.
- Crisis Management Teams: Establishing specialized teams trained to handle various emergency scenarios efficiently.

2.11. Comparative Analysis: Regulatory Compliance and Implementation Challenges in the Food Industry (Horlicks) vs. the Port Sector (KSPL)

Nature of Operational Hazards:

- Food Industry (Horlicks): Hazards primarily revolve around food safety, hygiene, and quality control. Chemical hazards may include exposure to cleaning agents or food additives.
- Port Sector (KSPL): Hazards are more diverse and physically intensive, including heavy machinery operation, cargo handling, and exposure to various chemicals and environmental elements.

Regulatory Environment:

- Food Industry: Governed by stringent food safety and quality regulations, nationally (e.g., FSSAI in India) and internationally. The focus is on maintaining hygiene standards, traceability, and consumer safety.

- Port Sector: Subject to various regulations, including maritime safety, environmental regulations, and labor laws. Compliance often involves adhering to national and international standards (e.g., ILO, IMO).

Compliance Complexity:
- Horlicks: Compliance is more standardized due to the uniform nature of production processes. Challenges might include maintaining consistent quality and safety across all units.
- KSPL: Faces more complex compliance challenges due to the variability of cargo, environmental factors, and the scale of operations. Ensuring consistency in safety practices across diverse operations is a significant challenge.

Workforce Training and Awareness:
- Food Industry: Training is often focused on hygiene practices, quality control procedures, and handling of food-grade materials.
- Port Sector: Requires more comprehensive training covering a wide range of safety protocols, handling of diverse equipment, and emergency response procedures.

Technological Integration:
- Horlicks: Technology is often used for quality control, traceability, and automating production lines to minimize human error.
- KSPL: Utilizes technology for logistics management, safety monitoring, and automating complex operations to enhance safety.

Infrastructure and Investment:
- Food Industry: Investment is often directed towards state-of-the-art manufacturing facilities, hygiene control systems, and quality testing labs.
- Port Sector: Requires significant investment in infrastructure like dockyards, equipment, safety gear, and environmental protection measures.

Stakeholder Engagement:
- Horlicks: Stakeholder engagement primarily involves suppliers, distributors, and consumers with a focus on quality and brand reputation.
- KSPL: Involves a broader range of stakeholders, including shipping companies, regulatory bodies, and local communities, with diverse interests ranging from operational efficiency to environmental impact.

Impact of Non-Compliance:
- Food Industry: Non-compliance can lead to health risks for consumers, significant legal liabilities, and brand reputation damage.
- Port Sector: Consequences include operational disruptions, significant safety hazards for workers and surrounding communities, and environmental damage.

2.12. Gaps in Literature: Unexplored Areas in Industrial Hygiene and Safety in the Food Industry (Horlicks) and Port Sector (KSPL)

Long-Term Health Impacts:
Limited Data on Chronic Effects: More long-term studies need to examine the chronic health impacts on workers in both sectors, especially concerning exposure to various chemicals and ergonomic hazards.

Mental Health Aspects: While physical safety is often discussed, the literature lacks a deep dive into the mental health implications of working in high-stress environments like ports or fast-paced manufacturing units.

Technological Advancements and Safety:
Impact of Automation: While some focus is on how automation impacts efficiency, more is needed to know about its long-term effects on worker safety and job security in both sectors.

Emerging Technologies: The role of advanced technologies (like Artificial intelligence and the Internet of Things) in enhancing workplace safety still needs to be researched.

Small-Scale Operations and Informal Workers:
Informal Sector Compliance: Studies often overlook the informal sectors within these industries, like small-scale suppliers or temporary dock workers, where compliance might be significantly lower.

Safety in Small and Medium Enterprises (SMEs): Particularly in the food industry, implementing safety standards in smaller enterprises (like local suppliers for Horlicks) needs to be well-documented.

Environmental Sustainability and Worker Safety: Intersection with Environmental Health: There needs to be more understanding of how environmental sustainability efforts intersect with worker safety, particularly in the port sector.

Climate Change Effects: The impact of climate change on operational safety and worker health in these industries is an emerging area that requires more attention.

Gender-Specific Challenges:
Women in the Workforce: Specific challenges women face, especially in the traditionally male-dominated port sector, should be more extensively covered.

Gendered Approach to Safety: An under-explored area is how safety protocols must be tailored to address gender-specific needs.

Cultural and Regional Variations:

Cultural Influence on Safety Practices: The impact of cultural factors on the implementation of safety standards is rarely discussed.

Regional Compliance Variability: More detailed studies on how compliance varies across different regions within India, considering the vast geographical and cultural diversity, are needed.

Policy Implementation and Effectiveness:
Gap Between Policy and Practice: While there is literature on what policies exist, more is needed to know about their real-world effectiveness and implementation challenges.

Best Practice Case Studies: More in-depth case studies are needed to showcase the successful implementation of safety standards.

Emergency Preparedness and Response:
Crisis Management Studies is a Detailed analysis of emergency response preparedness, and crisis management is limited, especially in high-risk areas like ports.

Learning from Incidents: Documentation and analysis of past incidents to inform better safety practices must be sufficiently explored.

2.13. Summary of Findings from the Literature

Operational Hazards and Compliance: Both the food industry (Horlicks) and the port sector (KSPL) face distinct operational hazards, requiring adherence to specific regulatory frameworks. The food industry focuses on hygiene and quality control, while the port sector deals with a broader range of safety issues, including cargo handling and environmental factors.

Regulatory Environment Complexity: Compliance in both sectors is challenged by the complexity of national and international regulations. The food industry primarily deals with food safety and quality regulations, whereas the port sector navigates a more diverse regulatory landscape, including maritime safety and environmental regulations.

Workforce Training: Effective training and awareness programs are crucial in both sectors. The food industry emphasizes hygiene and quality control training, while the port sector requires comprehensive safety training due to diverse operational risks.

- Stakeholder Engagement: The engagement of various stakeholders, including employees, regulatory bodies, and local communities, plays a significant role in implementing safety standards in both sectors.

- Challenges in Compliance and Best Practices: Compliance challenges in both sectors vary, with the food industry grappling with maintaining consistent quality and the port sector facing complex safety and environmental challenges. Best practices include comprehensive safety management systems, regular training, and technological advancements in the food industry.

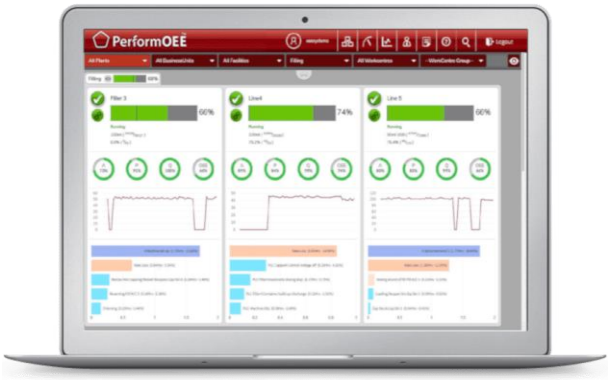
3. ADVANCED EQUIPMENT IN INDUSTRIAL HYGIENE

3.1. Advanced Equipment's

Advanced equipment in industrial hygiene refers to integrating sophisticated technologies and tools to enhance the identification, monitoring, and control of workplace hazards. These tools contribute to a more proactive, accurate, and efficient approach to industrial hygiene management. Here are several types of advanced equipment commonly used in industrial hygiene:

Real-time Monitoring Systems:

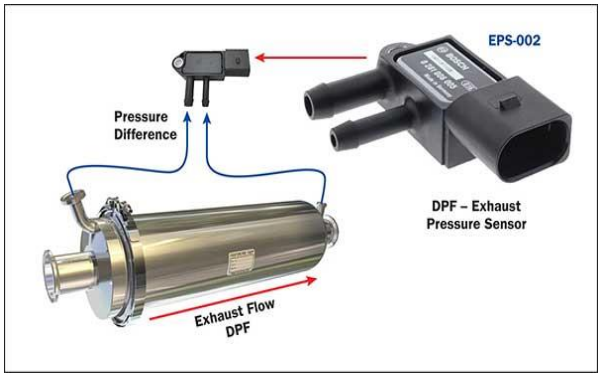
- Description: These systems provide continuous, instantaneous data on environmental conditions, allowing for immediate response to changes.
- Applications:
  - Monitoring airborne contaminants in real- time.
  - Tracking noise levels, temperature and humidity.
  - Detecting gas leaks and chemical releases.



(Figure.2. Real-time Monitoring System)

Sensor Technologies:

- Description: Advanced sensors are designed to detect specific hazards and provide real-time data for rapid decision-making.
- Applications:
  - Gas sensors for detecting volatile organic compounds (VOCs) and hazardous gases.
  - Particulate matter sensors for airborne dust monitoring.
  - Chemical sensors for identifying specific chemical exposures.



(Figure.3. Sensor Technologies)

Personal Monitoring Devices:

- Description: Individuals can carry wearable devices to monitor their exposure to hazards in real-time.
- Applications:
  - Personal exposure monitoring for chemicals, noise, and particulate matter.
  - Integration with health monitoring systems for comprehensive worker well-being.

(Figure.3. Personal Monitoring Devices)

Drones and Unmanned Aerial Vehicles (UAVs):

- Description: Drones with sensors can access difficult-to-reach areas, providing valuable data without risking human safety.
- Applications:
  - Inspection of industrial facilities and confined spaces.
  - Aerial monitoring of environmental conditions in large areas.

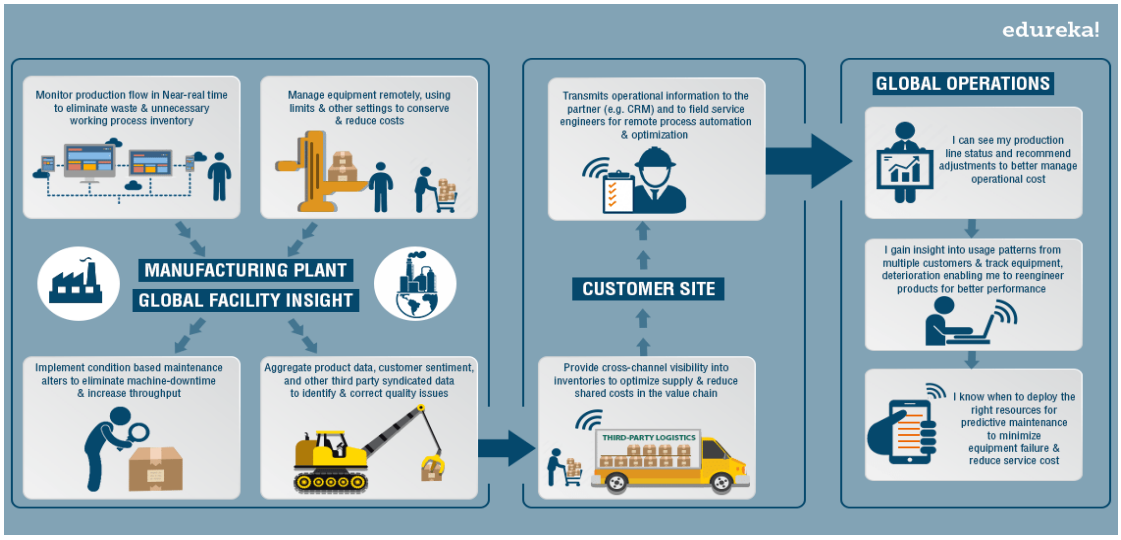
(Figure.4. Drones and Unmanned Aerial Vehicles)

Data Analytics and Big Data:

- Description: Advanced data analytics tools process large datasets to identify patterns, trends, and potential hazards.
- Applications:
    - Predictive modelling for anticipating future exposures.
    - Analysing historical data for trend identification.
    - Integrating data from multiple sources for an in-depth risk assessment.

Artificial Intelligence (AI) and Machine Learning:

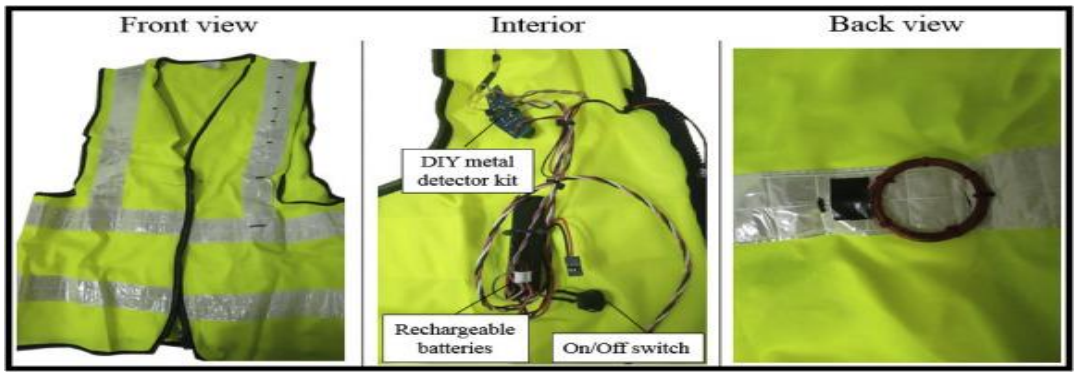
- Description: AI algorithms can analyse complex data sets, learn from patterns, and make predictions or recommendations.
- Applications:
    - Predictive modelling for identifying potential hazards.
    - Automated data analysis for rapid decision-making.
    - Developing adaptive control measures based on evolving conditions.



(Figure.5. Artificial Intelligence (AI) and Machine Learning)

Innovative PPE (Personal Protective Equipment):

- Description: Wearable technologies are integrated into traditional PPE to provide additional protection and real-time monitoring.
- Applications:
    - Smart respirators that monitor breathing patterns and filter efficiency.
    - Intelligent clothing with embedded sensors for heat stress monitoring.



(Figure.6. Innovative PPE (Personal Protective Equipment))

Augmented Reality (AR) and Virtual Reality (VR):

- Description: AR and VR technologies provide immersive training experiences and aid in visualizing complex scenarios.
- Applications:
    - Virtual simulations for training on hazard recognition and control.
    - AR overlays for real-time information on workplace conditions.

Remote Monitoring and Telemetry:

- Description: Remote systems allow for continuous monitoring and control of industrial processes and conditions.
- Applications:
    - Remote monitoring of industrial facilities for environmental conditions.
    - Telemetry systems for tracking and controlling equipment from a central location.

(Figure.7. Remote Monitoring and Telemetry)

Biological Monitoring Devices:

- Description: Devices that monitor biological markers to assess exposures and health effects.
- Applications:
    - Biological monitoring for assessing exposure to chemicals.
    - Wearable biosensors for continuous health monitoring.

(Figure.8. Biological Monitoring Device)

Mobile Applications:

- Development of mobile apps that allow workers and managers to monitor environmental conditions and receive alerts on their smartphones or tablets.
- Apps can also be used for training, reporting hazards, and accessing safety procedures and guidelines.
- APP 1: Vera EHS (audit and inspection tools, quick and easy accident reporting, online training courses, recordkeeping, document capture, and more.
- APP 2: NIOSH PPE Tracker (Keep track of your inventory of goggles, respirators, and other personal protective equipment

3D Printing:

- Customizable and on-demand production of safety equipment and parts for ventilation systems or other hygiene-related machinery.
- Reducing the time and cost associated with procuring specialized safety equipment.

(Figure.9. 3D Printing)

3.2. Case Studies: Industries that have Successfully Implemented Advanced Equipment

Implementing advanced equipment in Indian industries has contributed significantly to the country's industrial growth and efficiency. Here are a few case studies that highlight successful equipment implementation in various sectors in India:

Company: Maruti Suzuki

Automotive Industry - Robotics in Manufacturing Maruti Suzuki, a leading automotive manufacturer in India, implemented robotic automation in their manufacturing processes. Using robotics has enhanced the assembly line's precision, efficiency, and productivity. This implementation led to a significant increase in production volumes while maintaining high-quality standards. This adoption of robotics also helped in reducing human error and improving worker safety.

Company: Arvind Mills
Textile Industry - Automated Spinning Technology

Arvind Mills, one of India's largest textile manufacturers, adopted automated spinning technology to improve the quality of yarn and fabric production.

The technology not only increased the production capacity but also improved the consistency and quality of the products. It allowed Arvind Mills to compete globally by meeting international quality standards.

Company: Sun Pharma
Pharmaceutical Industry - Advanced Drug Manufacturing Equipment

Sun Pharma invested in state-of-the-art drug manufacturing equipment to streamline its production process and adhere to global quality standards.

This led to enhanced efficiency in drug production, better control of processes, and compliance with stringent international regulatory standards. It enabled Sun Pharma to expand its market reach globally.

Agriculture Sector - Precision Farming Equipment:

The introduction of precision farming equipment, including GPS-guided tractors and drones for crop monitoring, has been adopted by progressive farmers across India.
Outcome: These technologies have led to more efficient farming practices, better crop yields, and reduced waste. Precision farming has also helped in optimizing the use of water and fertilizers, contributing to sustainable farming practices.

Company: Reliance Industries
Information Technology - Data Centre Modernization

Implementation: Reliance Industries upgraded its data centres with advanced server and networking equipment to support its vast digital services and data storage needs.

Outcome: This modernization resulted in enhanced data processing capabilities, improved energy efficiency, and better scalability to meet the growing demands of their digital services.

Company: Adani Green Energy

Renewable Energy - Solar Power Technology:

Implementing cutting-edge solar power technologies, including high-efficiency solar panels and automated solar tracking systems.

This significantly increased power generation efficiency and contributed to India's goal of expanding its renewable energy capacity.

These case studies demonstrate how adopting advanced equipment and technology can significantly improve safety, productivity, quality, and efficiency in various industries in India. The success of these implementations also underscores the importance of embracing technological advancements to stay competitive in the global market.

3.3. The correlation between industrial hygiene, advanced equipment, and economic development

Implementing advanced equipment in industrial hygiene practices can, directly and indirectly, affect economic development**.**

Improved Worker Productivity and Health:

- Industrial Hygiene Impact: Ensuring a healthy and safe work environment through industrial hygiene practices reduces the risk of occupational illnesses and injuries.
- Advanced Equipment Contribution: Implementing advanced equipment for hazard monitoring and control enhances worker safety, improving health and increasing productivity.

Reduction in Absenteeism and Healthcare Costs:

- Industrial Hygiene Impact: Effective industrial hygiene practices reduce the occurrence of workplace-related illnesses and injuries, minimizing absenteeism.
- Advanced Equipment Contribution: Advanced equipment can prevent exposure to harmful substances, thus reducing healthcare costs and the economic burden on individuals and the healthcare system.

Enhanced Compliance and Risk Management:

- Industrial Hygiene Impact: Adhering to industrial hygiene standards and regulations minimizes legal risks, ensuring a compliant and ethical business operation.
- Advanced Equipment Contribution: Cutting-edge monitoring and control equipment help in real-time compliance monitoring, reducing the risk of legal issues and associated financial penalties.

Attraction of Skilled Labour:

- Industrial Hygiene Impact: Industries with robust industrial hygiene practices are more attractive to skilled workers who prioritize workplace safety.
- Advanced Equipment Contribution: Demonstrating a commitment to safety through advanced equipment enhances the industry's appeal to skilled professionals, contributing to a highly skilled and efficient workforce.

Global Competitiveness:

- Industrial Hygiene Impact: Meeting or exceeding international industrial hygiene standards enhances the global competitiveness of industries.
- Advanced Equipment Contribution: The use of advanced equipment reflects technological sophistication, further bolstering the competitiveness of industries in the global market.

Innovation and Technological Advancement:

- Industrial Hygiene Impact: Prioritizing industrial hygiene fosters a culture of safety and accountability within the organization.
- Advanced Equipment Contribution: Investing in advanced equipment signifies a commitment to innovation, driving technological advancement, and contributing to economic growth.

Reduction in Work-related Fatalities:

- Industrial Hygiene Impact: A focus on industrial hygiene aims to reduce workplace hazards, preventing fatal accidents.
- Advanced Equipment Contribution: Implementation of advanced monitoring equipment can swiftly detect and respond to potential dangers, reducing the risk of work-related fatalities.

Community and Environmental Impact:

- Industrial Hygiene Impact: Responsible industrial hygiene practices consider the impact of industrial activities on surrounding communities and the environment.
- Advanced Equipment Contribution: Advanced monitoring and control equipment can help industries minimize their environmental footprint, contributing to sustainable development and positive community relations.

4. FIELD STUDY CONDUCTED AT KAKINADA SEAPORTS LIMITED AND HORLICKS (GSK) FACTORY:

4.1. INDUSTRY 1: Kakinada Sea Ports Limited (KSPL):

(Figure.10. Kakinada Sea Ports Limited)

The Government of Andhra Pradesh commissioned the Kakinada Deep Water Port in November 1997, with a quay length of 610 meters. When the port was privatized in 1999, Kakinada Seaports took over operations. After ten years, the port was expanded to 2,500 meters of quay length for handling different products and a stand-alone facility for offshore supplies for deep sea exploration.
Ideally located between Visakhapatnam and Chennai Ports, Kakinada boasts significant sea and land advantages that promote ready access to markets while protecting ships in port. The Hope Island, a natural formation, offers protection as a natural breakwater for Kakinada Port. 1.2 km breakwater of tetra pods provides tranquil bay conditions year-round, allowing vessels to operate in the sheltered waters of Kakinada Deep Water Port.
On land, the port is surrounded by the districts of Krishna, East and West Godavari, Guntur, and the entire Telangana region, where agricultural products, minerals, Coal, and fertilizers are produced in abundance, and major highways and railway lines connect to Kakinada.

- Kakinada Seaports Limited started port operations from 01-04 -1999.
- As a Corporate philosophy, Kakinada Seaports Limited has always used modern practices, systems, and technology to excel in Port Management.
- Kakinada Seaports Limited is ISO 9001, ISO 14001 & ISO 45001 Certified.

Berth Operations
A structure is built along or at an angle from the shore of navigable waters so that ships may lie alongside to receive and discharge cargo and passengers. KSPL has 19 berths, out of which 7 are for Offshore Supporting Vessels (OSV).

(Table.1. Berth Operations of Kakinada Sea Ports Limited)

Berth	Type of Cargo
North berth	Liquid Cargoes
Middle berth	Alumina, Rock Phosphate, Cement clinker
South berth (Old & New)	Bulk clay, Sugar, Coal, Wood chips, CP Coke
NRW 1	Edible oil, Raw Sugar, Crude Palm Oil
NRW 2	Granite, Sugar bags, Project Vessels, Rice
NRW 3	Sugar bags, Rice, Bentonite, Feldspar chips
IV-berth	Raw sugar, Bagged sugar, Granite handling, Fertilizers, Coal in bulk,
V-berth	Coal handling
VI- berth	Coal handling
VII-berth	Fertilizers
VIII-berth	Containers, Sugar, Rice

Warehouses & Yards

Warehouses are large buildings where raw materials or manufactured goods may be stored before distribution/transportation for various purposes.

(Figure.11. Warehouses & Yards)

Handling Facilities

Coking Coal facilities:
A deep draft berth in the outer harbour with a quay Length of 356 meters to handle vessels of draft up to 14.5 meters is available for handling imported coking Coal. The berth can handle 10000 DWT vessels, two floating cranes, and Bulk Express.

(Figure.12. Coking Coal facilities)

Shipping system:
The shipping system reclaims the cargo from the stacks and conveys it through the conveyors to the ship loader for loading into the ships' hatches. The system consists of 3 bucket wheel recliners with 4000 tonnes per hour capacity and a long overhead conveyor system (4.8 km – one way).

(Figure.13. Shipping system)

Logistics
Road network:
A Road running within the Port land was commonly used historically over a long period by the Port Cargo Traffic and the City public between the Port area up to NH-16.

Facilities in KSPL

Double Integrity Cup Storage Tank:

The DWDI tank with insulation on the outer tank can be operated longer even when an inner tank fails. The tank with insulation in the annular space needs to be decommissioned when the inner tank fails since its outer tank is not insulated.

(Figure.14. Double Integrity Cup Storage Tank)

Chemical Pressure and Temperature Indicators:

(Figure.15. Chemical Pressure and Temperature Indicators)

Ammonia Gas Detector at - U Bend Area:

(Figure.16. Ammonia Gas Detector)

4.2. INDUSTRY 2: GlaxoSmithKline (GSK) – Horlicks Factory

Company Profile

GSK is an associate of GlaxoSmithKline plc. of the UK, a global science-based healthcare company. GSK has continually benefited from the technical and marketing inputs available due to this association. GSK is the most significant player in the health food drinks industry. The Company's manufacturing units in Nabha, Rajahmundry, have a workforce of about 2700 people.

In India, GSK has a strong marketing and distribution network, including over 2,200 wholesalers and direct coverage of over 5,15,000 retail outlets. Its signature product, Horlicks, has been a widely regarded and highly respected brand for over 100 years.

50% of workers were made permanent, and casuals were enrolled as per requirement. The Union of Workmen came into existence a few years after its inception. The plant currently has a workforce varying from 1500 to 2000, of which approximately 1115 are permanent.

Products Manufactured

Different types of products such as Horlicks, Vanilla Horlicks, Horlicks Lite, Horlicks Elaichi, Junior Horlicks, Junior Horlicks Chocolate, Boost Malt Drink, Boost Choco Blast, Mother's Horlicks are manufactured based on the requirement.

Manufacturing Process of Horlicks-like Product

Raw Material Procurement:

- The process begins with procuring raw materials like milk powder, malt extract, wheat flour, minerals, vitamins, and sugar.

Mixing and Blending:

- These ingredients are then accurately weighed and mixed. High precision in mixing is crucial for consistency in the final product.

Cooking and Drying:

- The mixture is often cooked through extrusion, where it is subjected to high temperatures and pressures.
- After cooking, the product is dried to reduce moisture content, essential for increasing shelf life.

Milling:

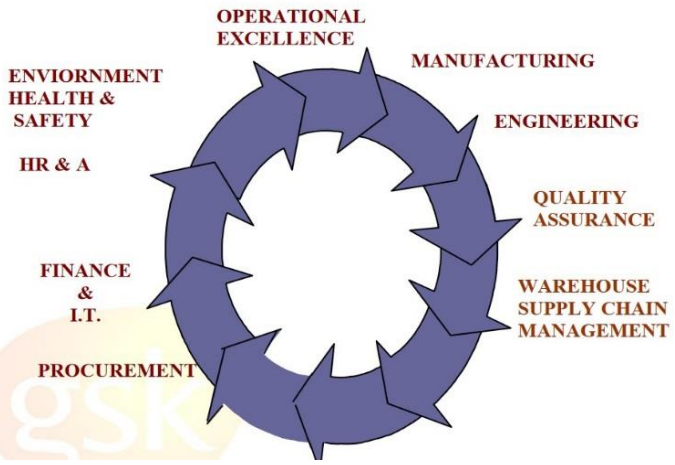
- The dried product is milled into a fine powder.

Quality Control:

- Samples are taken for quality control, where they are checked for taste, solubility, and nutritional content.

Packaging:

- The final product is packaged in a sterile environment to ensure no contamination. This could involve vacuum packing or sealing in moisture-proof packaging.



(Figure.17. Horlicks factory management)

Good Manufacturing Practices (GMP) in Food Processing

Facility Design and Maintenance:

- Facilities are designed to minimize contamination risks with smooth, easily cleanable surfaces.
- Regular maintenance schedules are maintained to ensure that machinery and equipment are in good working order.

Personal Hygiene:

- Strict personal hygiene protocols for all staff, including hand washing, protective clothing, hairnets, and footwear.
- Training and reinforcement of personal hygiene practices among employees.

Cleaning and Sanitation:

- Regularly and thoroughly clean and sanitize all equipment, surfaces, and facilities.
- Use appropriate cleaning agents and sanitizers that are effective yet safe for food processing environments**.**

Pest Control:

- An effective pest control program to prevent contamination from rodents, insects, and other pests.

Control of Raw Materials:

- Strict quality control of raw materials entering the facility, ensuring they meet safety standards.
- Proper storage and handling of raw materials to prevent cross-contamination**.**

Process Controls:

- Monitoring and controlling critical points in the manufacturing process to ensure product safety and quality.
- Regular calibration of equipment like thermometers, scales, and pH meters**.**

Allergen Management:

- Proper management and segregation of allergenic materials to prevent cross-contamination**.**

Waste Management:

- Effective waste disposal systems to prevent accumulation and potential contamination**.**

Industrial Hygiene Practices which are being implemented

Air Quality: Maintaining good ventilation to ensure a healthy working environment is crucial in processing areas where powders (like Horlicks mix) are handled.

Noise Control: Implementing measures to control noise from machinery, which can be a health hazard for workers**.**

Chemical Safety: Proper storage, labelling, and handling of chemicals used in the cleaning and maintenance.

Ergonomics: Designing workstations and workflows to reduce physical strain and prevent musculoskeletal disorders among workers.

Health and Safety Training: Regular training programs for employees on health and safety practices, emergency procedures, and correct use of protective equipment.

Monitoring and Auditing: Regular internal and external audits to ensure compliance with GMP and industrial hygiene practices**.**

Employee Welfare: Facilities and policies in place for employee welfare, including first aid, health check-ups, and comfortable break areas

5. METHODOLOGY

Research
Research is a process in which the researcher seeks to find out the final outcome for a given problem, and the solution aids in future course of action. The definition of research is "a careful investigation or enquiry, especially through the search for new facts in any field of knowledge."

Research Methodology
Methodology refers to the method by which researchers go about their work of describing, explaining, and forecasting happenings. Methods compromise the procedures used to generate, gather, and evaluate data. Methods are the ways of collecting information that can be used to assess explanations.

The following steps are involved in this study:
1. Formulating the study's objectives.
2. Defining the population and choosing a sample.
3. Designing a data collecting method.
4. Data analysis.
5. Conclusion and recommendations for further improvement in the practices

Research Design

The research design specifies the strategy and procedure for gathering the information needed to solve the problem. The research design was used for this study is mixed methods approach to find a solution to an existing problem. The purpose of this study is to find out the effectiveness of Importance of industrial hygiene at Port (KSPL) & Food industry (Horlicks).

Data Collection Method

Survey method is considered the most effective methods for data collection. The tools used for data collection are Questionnaire & Exposure monitoring using various devices and survey method to identify various hazards at workplaces.
In this method a questionnaire is collected through personal interview. A questionnaire consists of a number of questions involves both specific and general question related to Industrial hygiene importance.

Sources of Data

The two sources of data collection are primary & secondary.

- **Primary data**

Primary data are fresh data collected through Real time exposure monitoring with using advanced tools and survey from the employee's, using questionnaire.

- **Secondary data**

Secondary data are collected from books, industries manuals, internet government apps and various journals, magazines etc.

Statistical Tools Used
The important statistical tools used for the collection and analyses of data in this study are:

- Questionnaire
- Pie Charts
- Bar Diagrams

5.1. EXPOSURE MONITORING IN PORT AND FOOD INDUSTRIES

Exposure monitoring in the Port and Food industries is very essential to ensure the safety and health and safety of workers who are potentially exposed to various hazards, including harmful chemicals, noise, dust, and ergonomic risks. Proper equipment is essential for accurately measuring and monitoring these exposures.

5.1.1. Chemical Exposure Monitoring in Port Industry

Chemical exposure monitoring in the port industry involves a systematic process to assess and control potential hazards in various work areas.

- **Identified Hazardous Areas**: Different areas in the port facility where the chemical exposure hazards exist are identified. This could include cargo handling areas, storage facilities, tanker unloading areas, and maintenance zones.

- **Select Monitoring Methods and Equipment:** Gas detectors and multi-gas monitors for areas with potential gas leaks and personal sampling equipment for monitoring individual worker exposures, Direct-reading instruments (e.g., PID, FID) for real-time monitoring of volatile organic compounds (VOCs) or hazardous gases.

- **Established Monitoring Locations**: Determined the locations within each area where monitoring equipment is placed, or workers will wear personal monitoring devices. They considered some critical factors, such as proximity to potential sources of exposure and worker activities**.**

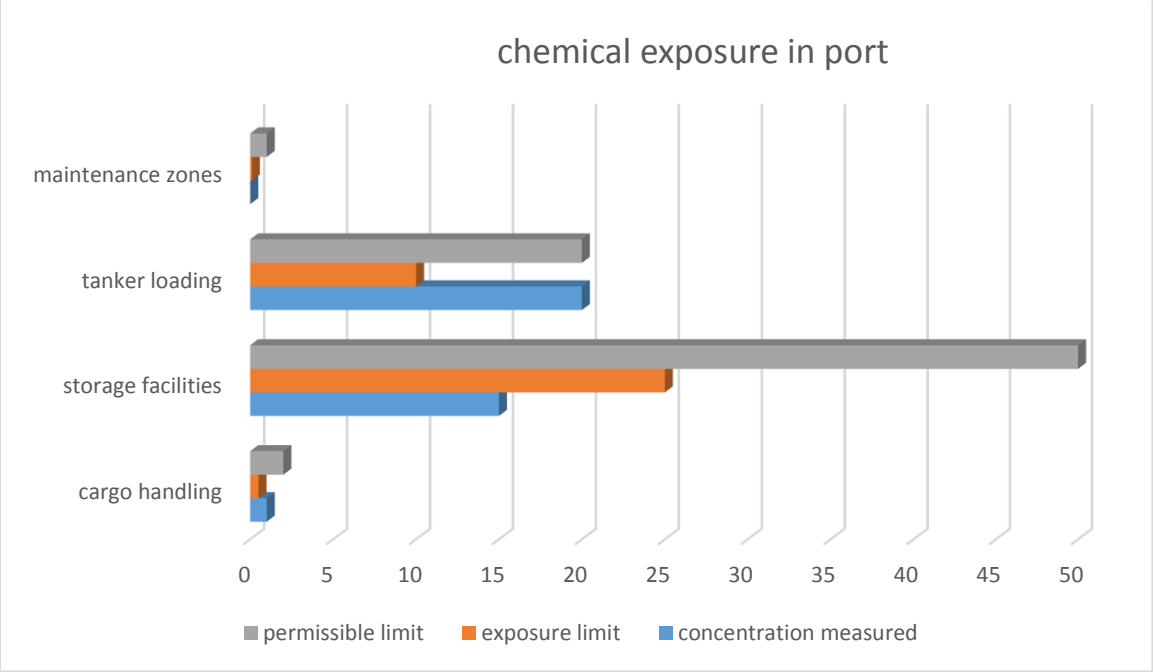
- **d. Sampling Protocol:** Developed a sampling protocol that outlines the frequency and duration of monitoring and the specific chemicals or parameters measured.

- **e. Data Collection & Analysis:** The monitoring equipment was deployed, sampling was conducted according to the established protocol and analysed the collected data with permissible exposure limits.

(Table.2. Chemical Exposure Monitoring in Port Industry)

Date	Area	Identified chemical	Concentration measured	Exposure limit	Permissible limit	Monitoring Method	Results
21/09/2023	Cargo handling	Benzene	1ppm	0.5 ppm	1ppm	Air Sampling	Within limit
21/09/2023	Storage facilities	Ammonia	15 ppm	25 ppm	50ppm	Direct reading	Within limits
22/09/2023	Tanker unloading areas	Hydrogen sulphide	20 ppm	10 ppm	20ppm	Drager tube	Exceed limit
23/09/2023	Maintenance zones	asbestos	0.01 fibres/cm3	0.1 fibres/cm3	1 fibres/cm^3	Filter sampling	Within limit

- Date: The date when the monitoring was conducted.
- Area: Specific area in the port where the monitoring took place.
- Identified Chemical: The chemical that was monitored.
- Concentration Measured: The level of the chemical found during monitoring.
- Exposure Limit: The maximum amount of the chemical concentration to which workers can be exposed without having adverse health effects, often based on OSHA standards or other regulatory bodies.
- Permissible Limit: The legal limit for exposure to the chemical, which might be the same as or different from the exposure limit.
- Monitoring Method: The technique or equipment used for measuring the chemical concentration (e.g., air sampling, direct reading instruments, Dräger tubes, filter sampling).



(Figure.18. Chemical Exposure Monitoring in Port Industry Graph)

Analysis:

- The average concentration of Benzene is well below the ACGIH TLV and OSHA PEL, indicating suitable control measures. Continued monitoring is essential to ensure long-term compliance and worker safety**.**
- The average concentration of Ammonia is below the ACGIH TLV& OSHA PEL, indicating compliance with the exposure limit. However, continued monitoring and control measures are advisable to maintain worker safety.
- The peak concentration of Chemical Hydrogen sulphide exceeded the ACGIH TLV. Immediate action is needed to reduce exposure levels and protect worker health. Frequent monitoring is essential.
- Asbestos fibre concentration is significantly below the ACGIH TLV, indicating a low-risk exposure. Workers are generally well-protected against this chemical.

(Figure.19. Chemical Exposure Monitoring areas and device)

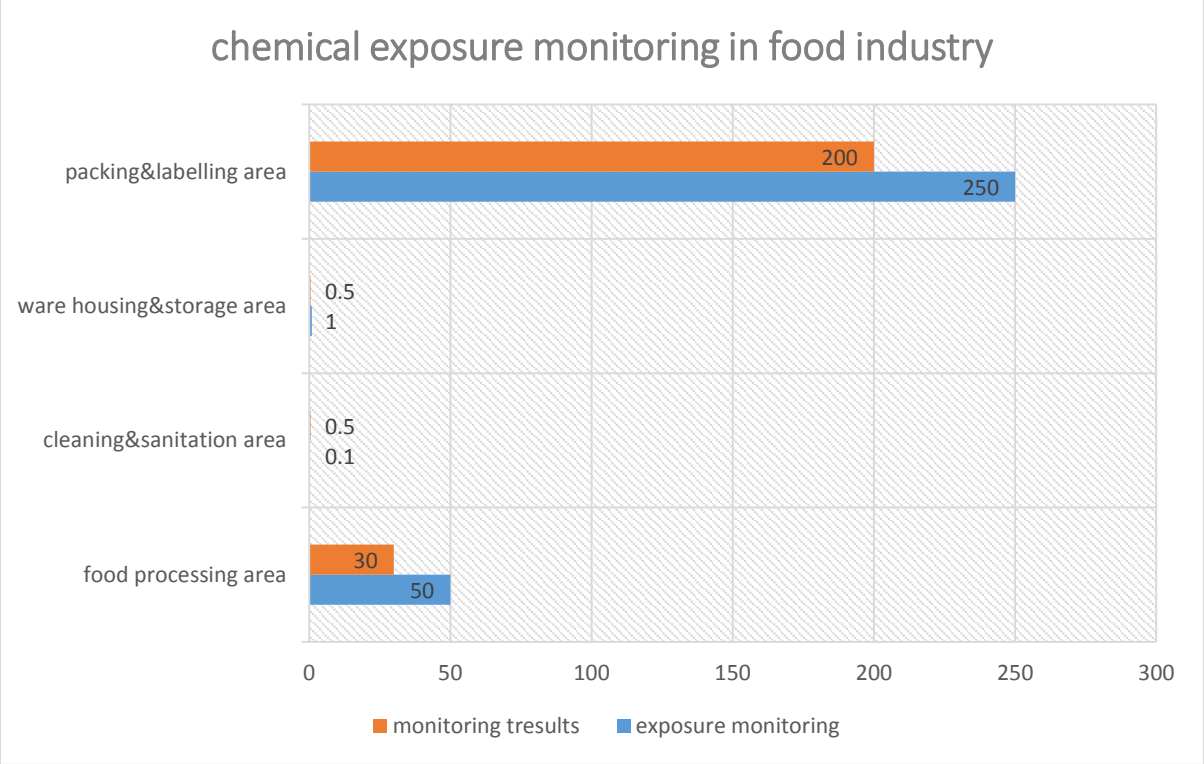
5.1.2. Chemical Exposure Monitoring in Food (Horlicks) Industry

Identification of Chemical Hazards: Begin by identifying potential chemical hazards in food processing areas, cleaning and sanitation areas, ware housing &storage areas.

(Table.3. Chemical Exposure Monitoring in Food (Horlicks) Industry)

Date of Monitoring	**Area**	**Identified Chemical**	**Exposure Limit (ppm or mg/m³)**	**Monitoring Results**	**Compliance Status**
14/09/2023	Food processing area	Ammonia	50 ppm	30ppm	Within limits
17/09/2023	Cleaning &sanitation area	Iodine	0.1 mg/m3	0.5mg/m3	Exceed limits
21/09/2023	Ware housing &storage area	Ethylene	1 ppm	0.5 ppm	Within limits
23/09/2023	Packing &labelling area	Ink solvents (acetone)	250ppm	200ppm	Within limits

- **Identified Chemical**: Specific chemicals that are used or present in each area. This includes cleaning agents, processing aids, gases used in refrigeration, etc.
- **Exposure Limit**: The regulatory or recommended maximum amount of the chemical to which workers should be exposed. This can be based on ACGIH guidelines, local regulations, or industry best practices.
- **Monitoring Results**: Actual measured chemical levels in the air or environment during the monitoring process.
- **Date of Monitoring:** The date when the monitoring was conducted.
- **Compliance Status**: Indicates whether the monitored levels are within the permissible exposure limits, ensuring safety and regulatory compliance.



(Figure.20. Chemical Exposure Monitoring in Food (Horlicks) Industry- Graph)

Sample collected areas:

(Figure.21. Chemical Exposure Monitoring areas in Food (Horlicks) Industry)

Monitoring device used:

(Figure.22. Chemical Exposure Monitoring device in Food (Horlicks) Industry)

Analysis

An essential assessment of the monitoring results indicates whether the levels are safe or if action is needed, and it may also suggest further steps or preventive measures.

- **Food Processing Areas**: Ammonia Results are within safe limits, so ongoing monitoring is recommended
- **Cleaning & Sanitation Areas**: Exceeds permissible exposure limit; immediate corrective action required to reduce exposure limits.
- **Warehousing & Storage Areas**: Within permissible limits; ensure proper ventilation to maintain safety.
- **Packaging & Labelling Areas**: Results indicate safe handling

5.1.3. Noise Exposure Monitoring in Port Industry

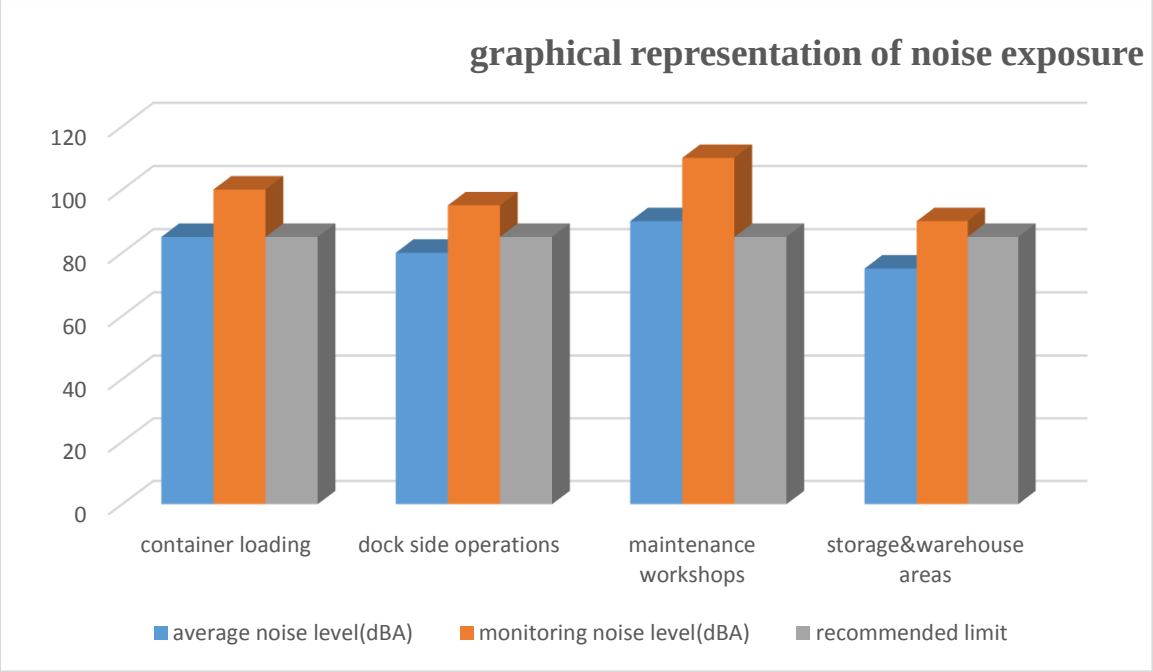
Noise Exposure Monitoring in Port

Noise exposure monitoring in the port industry is crucial due to the high noise levels generated by machinery, equipment, and operations in this environment. Port workers are often exposed to noise from container handling, ship engines, and other industrial activities. Monitoring and managing noise levels is essential to protect their hearing and comply with occupational health and safety regulations.

(Table.4. Noise Exposure Monitoring in Port Industry)

Area	Source of Noise	Average Noise Level (dBA)	Monitoring Noise Level (dBA)	Date of Monitoring	Compliance Status
Container Loading	Cranes, Trucks	85 dBA	100 dBA	10/08/2023	Compliant
Dockside Operations	Ship Engines, Cargo Movement	80 dBA	95 dBA	12/08/2023	Compliant
Maintenance Workshops	Power Tools, Machinery	90 dBA	110 dBA	14/08/2023	Compliant
Administrative Offices	Ambient Noise from Operations	60 Dba	70 dBA	15/08/2023	Compliant
Storage and Warehouse Areas	Forklifts, Automated Systems	75 dBA	90dBA	16/08/2023	Complaint
Tanker Unloading Areas	Pumps, Machinery	82 dBA	98 dBA	18/08/2023	Complaint

- **Source of Noise:** This column identifies the primary sources of noise in each area.
- **Average Noise Level (dBA):** This is the average decibel level recorded during the monitoring period. Continuous or average noise exposure levels are crucial for assessing long-term exposure risks.
- **Monitoring Noise Level (dBA):** This indicates the highest noise level recorded, which is essential for identifying the potential for immediate hearing damage.
- **Date of Monitoring:** The date when the noise level monitoring was conducted.
- **Compliance Status:** Indicates whether the noise levels are within the permissible exposure limits as per regulatory standards



(Figure.23. Noise Exposure Monitoring in Port-Graph)

Analysis:

- At container loading, the average noise level in the dock area is 85 dBA. This exceeds the recommended ACGIH 8-hour Time-Weighted Average (TWA) limit of 85 dBA. Immediate action is required to reduce noise exposure, such as implementing engineering controls or providing hearing protection for workers. Regular monitoring should continue to assess the effectiveness of control measures.
- At Dockside Operations, this level exceeds the recommended exposure limit, indicating a high risk of noise-induced hearing loss for workers in this area. Engineering controls, such as noise barriers or quieter equipment, should be implemented urgently. Workers must also wear appropriate hearing protection.
- Frequent noise monitoring is essential to ensure that noise control is effective.

Noise sample collected area

Sound level meter

(Figure.24. Noise Exposure Monitoring area and device, Port)

5.1.4. Noise Exposure Monitoring in Food Industry

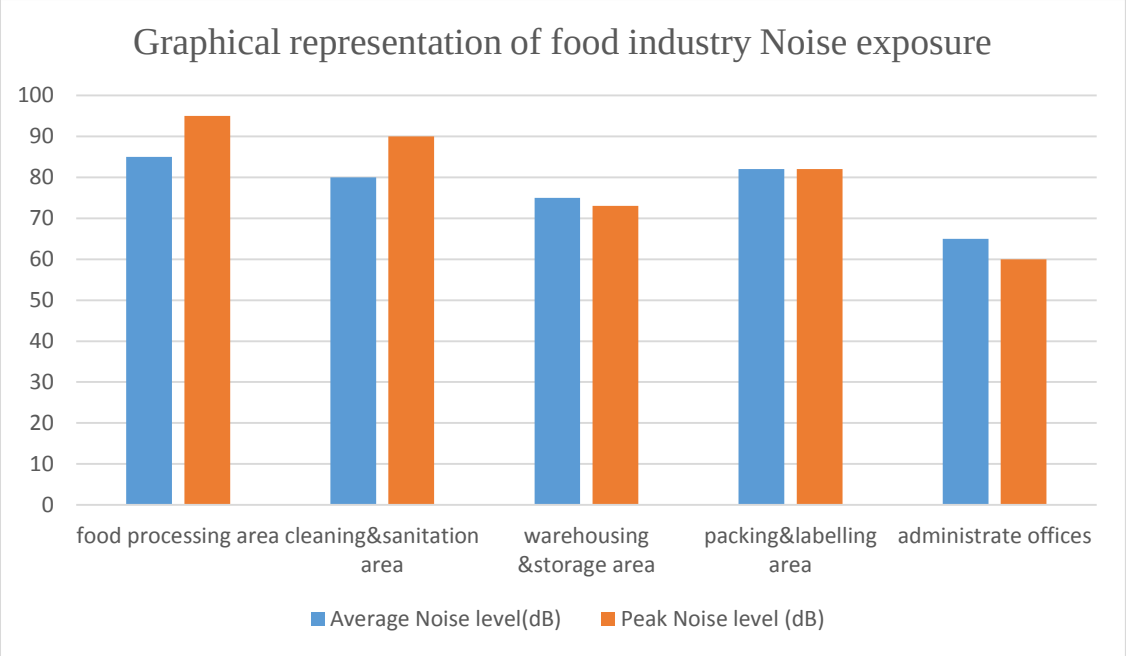
Conducting noise exposure monitoring in the food industry is essential for assessing the levels of noise employees are exposed to and ensuring that these levels are within safe and permissible limits.
The food industry often involves machinery and equipment that can generate significant noise, posing potential risks to hearing health**.**

(Table.5. Noise Exposure Monitoring in Food Industry)

Area	Noise Source	Average Noise Level (dB)	Peak Noise Level (dB)	Date of Monitoring	Compliance Status
Food Processing Area	Conveyors, Packaging Machines	85 dB	95 dB	26/08/2023	Compliant
Cleaning & Sanitation Area	High-Pressure Water Jets	80 dB	90 dB	24/08/2023	Compliant
Warehousing & Storage Area	Forklifts, Pallet Jacks	75 dB	73 dB	28/08/2023	Non complaint
Packaging & Labelling Area	Labelling Machines, Sealers	82 dB	82 dB	30/08/2023	Non-Compliant
Administrative Offices	General Office Noise	65 dB	60 dB	30/08/2023	Non-Compliant

Analysis:

- Food Processing Areas: These areas typically have the highest noise levels due to machinery and equipment. Although the levels are within limits, regular monitoring and hearing protection are recommended.
- Cleaning & Sanitation Areas: Noise levels are moderate but can peak due to specific activities. The use of ear protection during high-noise tasks is advisable.
- Warehousing & Storage Areas: The noise levels are lower compared to processing areas, but consistent monitoring is essential to ensure they remain within the safe limits.
- Packaging & Labelling Areas: These areas should be evaluated for potential noise reduction measures, such as installing sound-dampening materials or modifying equipment.
- Administrative Offices: Noise levels are typically low; however, maintaining a monitoring routine ensures a comfortable working environment.

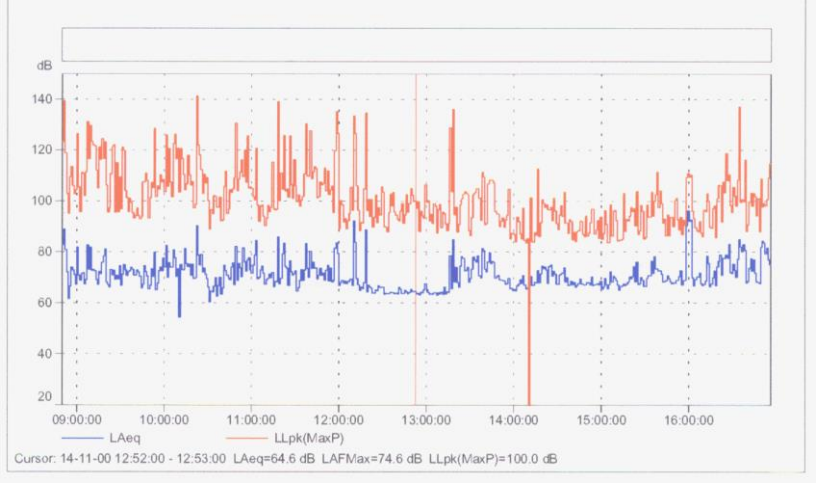


(Figure.25. Noise Exposure Monitoring in Food Industry-Graph)

Noise sample collected area

(Figure.26. Noise Exposure Monitoring area in Food Industry)

Audio graph of workers:



(Figure.27. Noise Exposure Audio Graph of workers in Food Industry)

5.1.5. Heat Stress Monitoring procedure in industries

Monitoring heat stress exposure is crucial for ensuring the safety and well-being of workers in hot and humid conditions. Heat stress can cause serious health issues such as heat exhaustion and heat stroke. The process of heat stress exposure monitoring involves several steps to assess and mitigate the risks associated with excessive heat exposure.

Identify the work areas where employees are exposed to high temperatures, indoors or outdoors, including construction sites, manufacturing facilities, agricultural fields, and more. Monitor weather conditions, including temperature, humidity, and heat index forecasts.

Identify the workers who are at a higher risk of heat-related illnesses. This includes new employees, older workers, those with certain medical conditions, and workers not acclimated to the heat.
Maintain the necessary equipment for heat stress monitoring, including:

- Wet Bulb Globe Temperature (WBGT) monitors for measuring environmental conditions, including temperature, humidity, and radiant heat.

- Personal Heat Stress Monitor: measure core body temperature and heart rate to assess individual heat stress levels.

Placement of Monitoring Equipment: Position WBGT monitors in various work areas and locations where workers spend the most time. Place personal heat stress monitors on workers to assess their individual heat exposure.

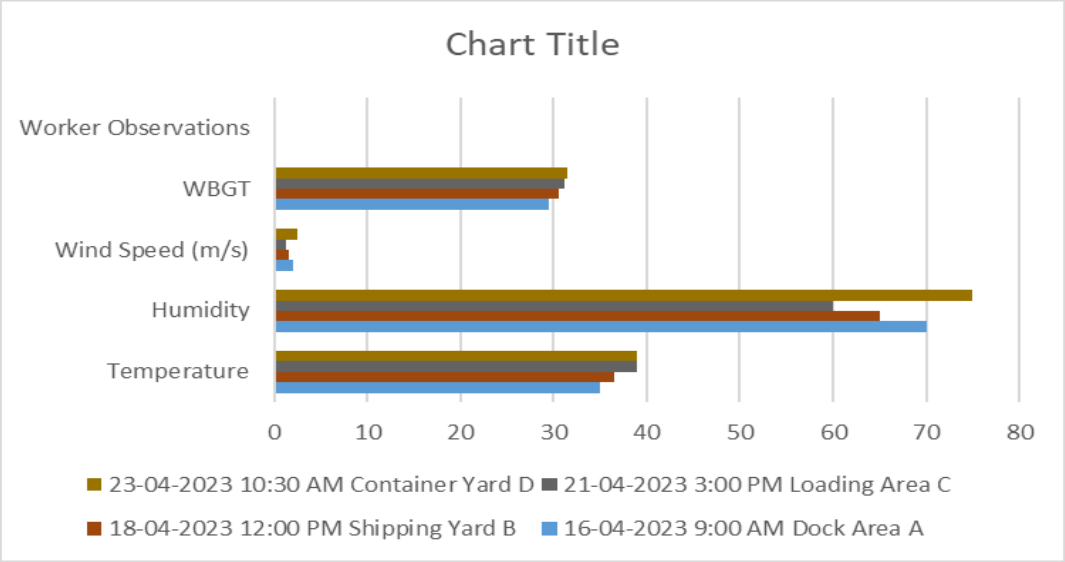
Continuously collect data from monitoring equipment, WBGT monitors provide real-time data on environmental conditions, while personal monitors record individual data.

5.1.5.1. Heat Stress Exposure Monitoring in Port (KSPL) Industry Using Wet Bulb Globe Thermometer

(Table.6. Heat Stress Exposure Monitoring in Port (KSPL))

Date	Time	Location	Temperature **(°C)**	Humidity **(%)**	Wind Speed (m/s)	WBGT Heat Index **(°C)**	Worker Observations
16/04/2023	09:00 AM	Dock Area A	35	70	2	29.5	- Workers reported feeling very hot and sweaty. Some workers showed signs of fatigue.
18/04/2023	12:00 PM	Shipping Yard B	36.5	65	1.5	30.5	- Workers complained of dizziness and excessive sweating. Some workers had flushed skin.
21/04/2023	03:00 PM	Loading Area C	39	60	1.2	31.1	- Workers reported feeling extremely uncomfortable and thirsty. One worker experienced nausea and vomiting.
23/04/2023	10:30 AM	Container Yard D	39	75	2.5	31.5	Workers mentioned feeling very hot, but no signs of distress were observed.

- **Location/Area:** The specific area or location within the port where monitoring is conducted.
- **Temperature (°C):** The air temperature measured in degrees Celsius.
- **Humidity (%):** Relative humidity as a percentage.
- **Wind Speed (m/s):** Wind speed measured in meters per second.
- **WBGT Index (°C):** The calculated Wet Bulb Globe Temperature index, which combines air temperature, humidity, wind speed, and radiant heat to assess heat stress**.**



(Figure.28. Heat Stress Exposure Monitoring Graph in Port Industry)

Analysis

At 09:00 AM, the WBGT reading is 29.5°C, which falls within the "Low" heat stress index category (0-80). Conditions are within safe limits for outdoor work.

At noon (12:00 PM), the WBGT further increased to 30.5°C, indicating "High" heat stress (91-103). Immediate action is required to protect workers, including providing shade, increasing rest breaks, and proper hydration measures.

The early afternoon (03:00 PM), the WBGT remains in the "High" category at 31.1°C. Frequent breaks and close monitoring of workers' heat stress levels are essential.

By 04:00 PM, there was a slight improvement with a WBGT reading of 31.5°C, categorizing it as "High" heat stress. Immediate action is essential to monitor workers and continue providing breaks and proper hydration measures.

Wet Bulb Globe Thermometer:

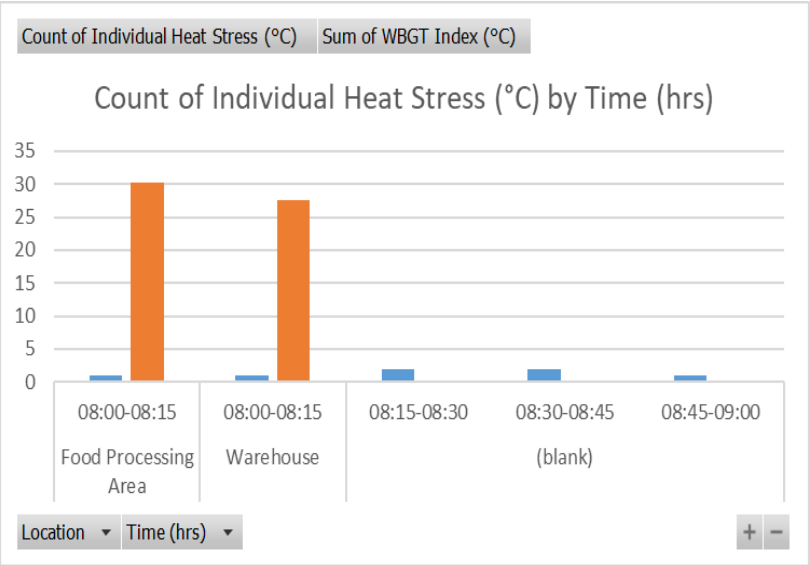
(Figure.29. Heat Stress Exposure Monitoring Device-Port Industry)

5.1.5.2. Heat stress exposure monitoring in Food (Horlicks) industry using Wet Bulb Globe Thermometer

(Table.7. Heat stress exposure monitoring in Food (Horlicks) industry)

Date	Time (hrs)	Location	WBGT Index (°C)	Individual Heat Stress (°C)	Analysis & Interpretation
05/05/2023	08:00-08:15	Food Processing Area	30.2	Worker A: 31.5	High WBGT index; Worker A's heat stress is elevated. Consider reducing workload or increasing breaks.
	08:15-08:30			Worker B: 29.8	Moderately high WBGT index; Worker B's heat stress is within acceptable limits.
	08:30-08:45			Worker C: 32.8	Very high WBGT index; Worker C's heat stress is dangerously high. Immediate action required (e.g., remove from heat).
	08:45-09:00			Worker D: 29.5	Moderately high WBGT index; Worker D's heat stress is within acceptable limits.
07/05/2023	08:00-08:15	Warehouse	27.6	Worker E: 28.2	Moderate WBGT index; Worker E's heat stress is within acceptable limits.
	08:15-08:30			Worker F: 29.8	Moderately high WBGT index; Worker F's heat stress is within acceptable limits.
	08:30-08:45			Worker G: 30.5	Moderately high WBGT index; Worker G's heat stress is within acceptable limits.

Graphical representation of heat stress in food industry



(Figure.30. Heat Stress Exposure Monitoring Graph-Food Industry)

Heat stress sample collected area Wet bulb globe thermometer

(Figure.31. Heat Stress Exposure Monitoring area, device – Food Industry)

Analysis

- The table presents heat stress exposure monitoring data for two days in a food processing area and a warehouse.
- The Wet Bulb Globe Temperature (WBGT) index is used to assess environmental conditions. A high WBGT index indicates elevated heat exposure risk.
- Individual heat stress values for workers (calculated from core body temperature or heart rate data) are provided.
- In the food processing area on 05/05/2023, Worker A and Worker C were exposed to high WBGT levels, indicating elevated heat stress. Immediate action is needed for Worker C to prevent heat-related illness. Worker A should also have a reduced workload or more frequent breaks.
- In the warehouse on 07/05/2023, the WBGT index was moderate, and all workers' heat stress levels were within acceptable limits.
- Regular monitoring helps identify areas and workers at risk, allowing timely interventions to prevent heat-related illnesses.

5.1.6. Ergonomic Exposure Monitoring in Industries

Ergonomic exposure monitoring in industries is crucial for identifying and mitigating workplace hazards that can lead to musculoskeletal disorders (MSDs) and other ergonomic-related injuries.

Identified tasks and work areas where ergonomic hazards are likely to exist more. This can include tasks that involve repetitive motions, heavy lifting, awkward postures, and prolonged sitting or standing.

Spoke with workers who perform the identified tasks. Gathered data on physical demands of their work, discomfort and pain.
Perform an ergonomic risk assessment for each identified task. Consider risk factors such as:

- Force: The amount of physical effort required.
- Repetition: The frequency at which tasks are performed.
- Posture: The positions workers are required to maintain.
- Vibration: Exposure to vibration from tools or equipment.
- Duration: The length of time workers spends performing tasks.

Utilize ergonomic assessment tools and software, such as the Rapid Entire Body Assessment (REBA), Rapid Upper Limb Assessment (RULA), and the NIOSH Lifting Equation, to quantitatively assess ergonomic risks. Collect data on ergonomic risk factors, including measurements, observations, and survey responses. Ensure the ergonomic exposure monitoring program complies with local regulations and industry standards.

5.1.6.1. Ergonomic exposure monitoring in port industry

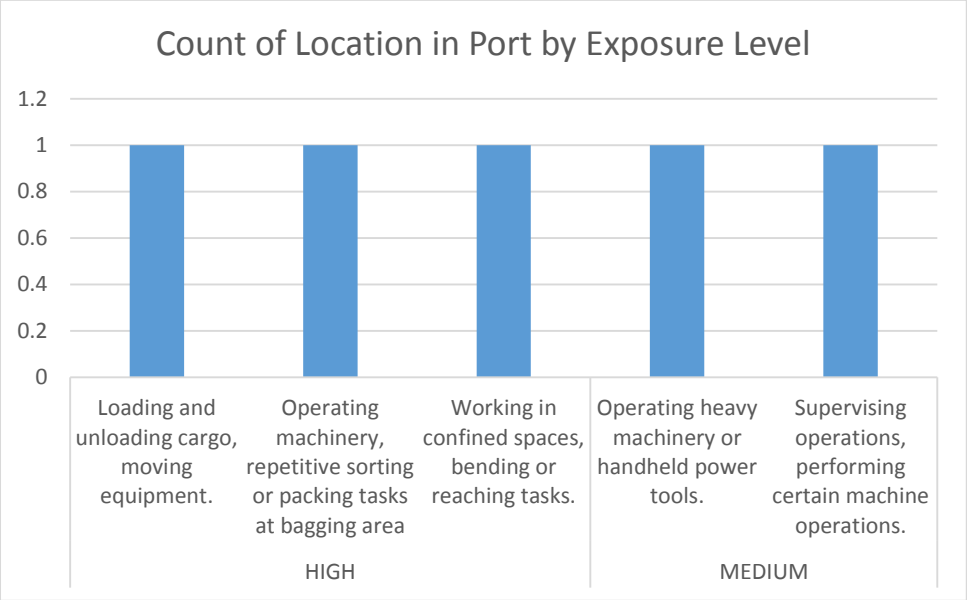
(Table.8. Ergonomic exposure monitoring in port industry)

Location in Port	Ergonomic Risk Factor	description	Common tasks in port industry	Measurement Method	Exposure Level
Loading Docks	Lifting Heavy Loads	Involves lifting, carrying, pushing, or pulling loads.	Loading and unloading cargo, moving equipment.	Observational analysis, use of lifting equations (NIOSH)	HIGH

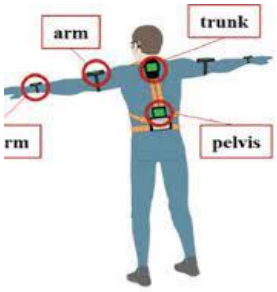
Storage Areas	Repetitive Motion	Repeatedly performing the same motion, leading to strain.	Operating machinery, repetitive sorting or packing tasks at bagging area	Time-motion studies, observational checklist self-reporting questionnaires.	HIGH
Control Rooms	Prolonged Sitting& standing	Standing for extended periods without significant movement.	Supervising operations, performing certain machine operations.	Observational studies, ergonomic mats usage assessment.	MEDIUM
Maintenance Area	Awkward Postures	Working in positions that strain the body	Working in confined spaces, bending or reaching tasks.	Posture analysis using video recording or wearable sensors. Ergonomic assessment tool RULA	HIGH
Crane Operation	Vibration Exposure	Exposure to whole-body or hand-arm vibration from tools or machinery.	Operating heavy machinery or handheld power tools.	Vibration measurement using hand-arm or whole-body meters	MEDIUM

Analysis:

- Manually lifting heavy loads Identified risk levels are high and identified risk of musculoskeletal disorders (MSDs), especially in the lower back, need for mechanical aids, work practice modification, and training to workers.
- For awkward posture: Identified high-risk tasks and potential ergonomic redesigns
- To repetitive motion: The exposure level is high, so evaluating the need for job rotation or ergonomic interventions is essential.
- To prolonged sitting and standing tasks: Assessing the exposure level is a medium need for anti-fatigue matting, and footwear recommendations.
- To vibration exposure: Determining the need for vibration damping controls or equipment maintenance.



(Figure.32. Ergonomic exposure monitoring in port industry – Graph)



(Figure.33. Ergonomic exposure monitoring in port industry)

5.1.6.2. Ergonomic Exposure Monitoring in Food Industry

Ergonomic exposure monitoring in the food industry to organize and understand the various ergonomic risks and potential interventions.

(Table.9. Ergonomic Exposure Monitoring in Food Industry)

Task in Food Industry	Ergonomic Risk Factors	Potential Health Impacts	Monitoring Methods	Exposure level
Grinding& mixing area	Repetitive motions, forceful exertions, awkward postures	MSDs in hands, wrists, shoulders, back	Motion analysis, ergonomic assessments	High

Packing& boxing	Repetitive movements, bending, lifting	Lower back and shoulder MSDs	Time-motion studies, posture analysis	Medium
Food manufacturing process are (GMP YARD)	Prolonged standing, repetitive hand movements	Leg, foot, and wrist disorders	Self-reported discomfort, observation	High
Conveyor belt operations	Static postures, repetitive tasks	Neck, back, and shoulder strain	Video ergonomic analysis	High
Macro oven operations	Lifting heavy trays, exposure to high heat	Back injuries, heat stress	Health records review, direct observation	Medium
Cleaning and maintenance	Bending, reaching, use of high-pressure hoses	Back and shoulder strain, hand-arm vibration	Ergonomic risk assessment	Medium
Quality control	Repetitive tasks, fine motor skills, visual inspection	Eye strain, hand and wrist disorders	Visual ergonomics assessment	Low

Analysis:

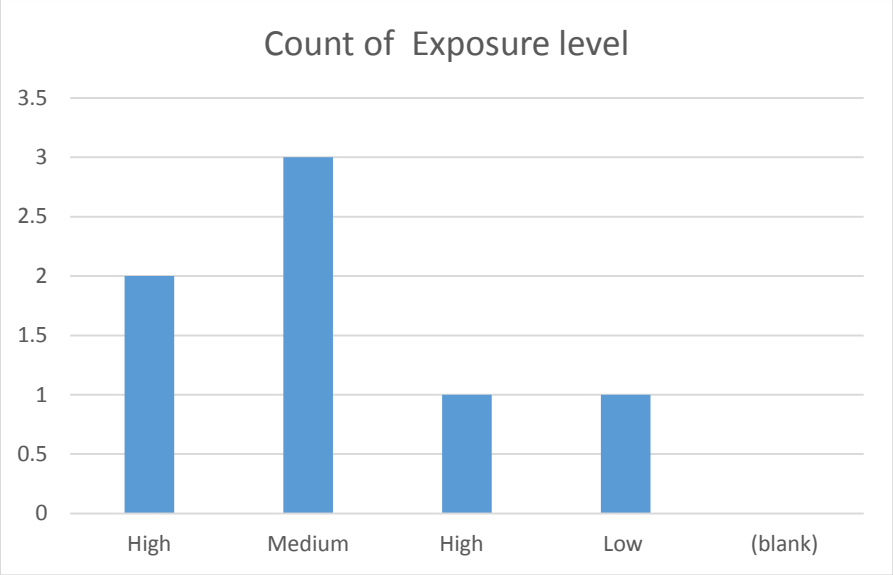
At grinding & and mixing areas, a High frequency of 8hrs repetitive tasks with severe awkward postures indicates a higher risk. Ergonomic interventions include adjustable workstations, and ergonomic tools.

A medium exposure range with repetitive bending and lifting was noted at the packing and boxing zone. Ergonomic training, mechanical lifting aids, and work rotations are implemented here.

At GMP yard and conveyor belt operation zones: Identified prolonged standing, and repetitive hand movements indicate high-risk exposure with lower back and shoulder MSDs. Ergonomic interventions include anti-fatigue mats, ergonomic utensils, adjustable conveyor heights, and breaks.

At macro-oven operations and maintenance areas: identified back injuries, heat stress, hand-arm vibration with medium exposure level need for heat stress management, long-handled tools, and adjustable nozzles.

At quality control, many employees have eye strain, and hand and wrist disorders with low risk. Need for visual ergonomic assessment.



(Figure.34. Ergonomic Exposure Graph Monitoring in Food Industry)

5.2. SURVEY REPORT ON IMPORTANCE OF INDUSTRIAL HYGIENE BASE QUESTIONNAIRE METHOD

(ANNEXURE – 1)

5.2.1 Purpose of the Survey

The primary purpose of this survey is to assess the level of awareness and perceived importance of industrial hygiene among employees within our organization. By understanding employee perceptions, the organization can identify potential areas of improvement in its industrial hygiene practices. This survey aims to gather insights into how employees view various aspects of industrial hygiene, including their knowledge of hazards, protective measures, and the effectiveness of current practices.

Survey Method: The survey was conducted using an online questionnaire, ensuring ease of access for all employees and allowing for efficient data collection and analysis**.**

5.2.2. Rationale for Selecting the Port Industry for Questionnaire Analysis

The decision to focus on the port industry for the questionnaire analysis in this study is grounded in several critical observations and findings that emerged during preliminary investigations. Firstly, an alarming pattern was noticed in medical examinations, particularly in the form of abnormal chest X-rays among port employees. This medical evidence indicates a higher incidence of respiratory ailments and other pulmonary conditions, which may be directly attributable to occupational exposure in the port environment.
Equally troubling is the observation that, despite having robust standards and training protocols in place, the port industry needs to pay more attention to the importance of maintaining dedicated industrial hygienists. This lack of specialized professionals in the field of industrial hygiene is a critical oversight, especially given the complex and potentially hazardous nature of work in port settings.

These combined factors, the observed medical anomalies and the absence of industrial hygiene professionals in the organizational structure – present a compelling case for the selection of the port industry as the focus of the questionnaire analysis. This analysis aims to delve deeper into these issues, identify the extent of knowledge gaps, assess the impacts of these deficiencies on worker health, and ultimately contribute to developing more effective occupational health strategies within the port industry.

(Figure.35. Practical Survey)

Respondent Demographics: The survey was conducted by considering 100 employees, representing a diverse cross-section of the organization. Respondents varied in terms of their departmental affiliations and years of experience, providing a comprehensive view across different levels and functions within the company.

- Departments included Manufacturing, Engineering, Quality Control, Human Resources, Sales and Marketing, and Finance and Administration.
- Experience levels ranged from new hires (0-2 years) to veterans (20+ years**)**

Nature of Questions: The questionnaire comprised multiple-choice questions designed to gauge both objective knowledge and subjective perceptions regarding industrial hygiene. Questions covered a wide range of topics, which includes awareness of workplace hazards, familiarity with safety protocols, and personal attitudes towards industrial hygiene practices.

5.2.3. Summary of Employee Demographics

Total Number of Employees Surveyed: 100
Department Distribution:

- Manufacturing: 30 Employees
- Engineering: 20 Employees
- Quality Control: 15 Employees
- Human Resources: 10 Employees
- Sales and Marketing: 15 Employees
- Finance and Administration: 10 Employees

Years of Experience:

- 0-2 years (New Hires): 30 Employees
- 3-5 years (Junior): 20 Employees
- 6-10 years (Mid-Level): 20Employees
- 20+ years (Veterans): 30 Employees

5.2.4. Questionnaire Overview

The questionnaire was designed to address a broad spectrum of topics related to industrial hygiene. The key themes and types of questions included in the survey were:

Awareness of Industrial Hygiene:

- Understanding of the term "industrial hygiene" and its relevance in the workplace.
- Familiarity with common workplace hazards (chemical, physical, ergonomic, biological).

Perceived Importance of Industrial Hygiene:

- Perceptions regarding the importance of industrial hygiene in maintaining a safe workplace.
- Personal attitudes towards health and safety practices.

Knowledge of Safety Protocols:

- Awareness of existing safety protocols and procedures in the organization.
- Understanding of personal protective equipment (PPE) usage and its importance.

Training and Education:

- Previous training received in industrial hygiene and safety.
- Interest in further training or education in this area.

Observance of Hygiene Practices:

- Regularity and thoroughness in following industrial hygiene practices.
- Observations of colleagues adhering to safety guidelines.

Feedback and Improvements:

- Suggestions for improving industrial hygiene practices in the workplace.
- Feedback on the current state of health and safety culture in the organization.

5.2.5. Data Analysis

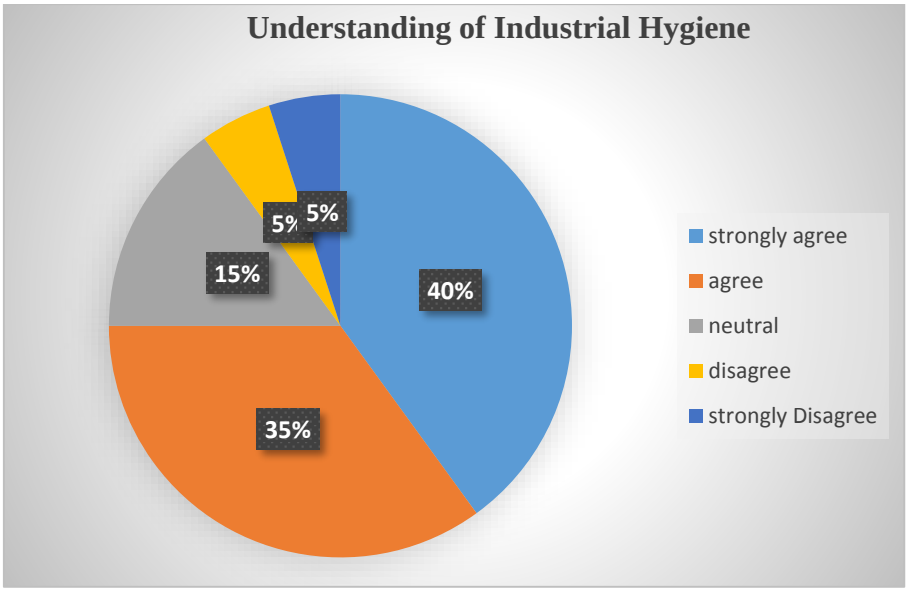
The data collected from the questionnaire was analysed to provide a clear picture of employee perceptions regarding industrial hygiene. Below is a summary of the findings:

Overall Responses

the survey consisted of five key questions, each with a response option ranging from "Strongly Disagree" to "Strongly Agree.

5.2.5.1. Understanding of Industrial Hygiene:

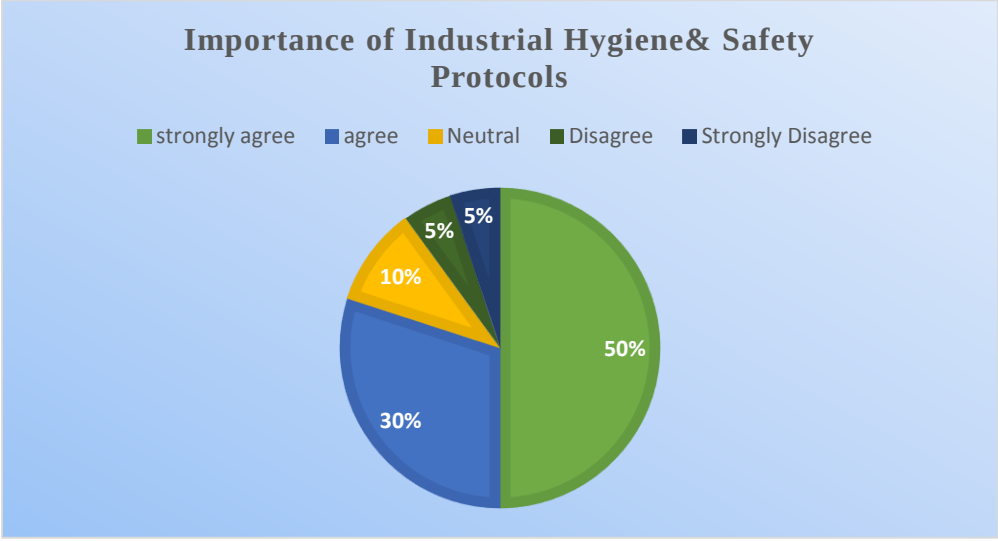
- Strongly Agree: 40%
- Agree: 35%
- Neutral: 15%
- Disagree: 5%
- Strongly Disagree: 5%



(Figure.36. Understanding of Industrial Hygiene-Survey Graph)

5.2.5.2 Perceived Importance of Industrial hygiene &Safety Protocols:

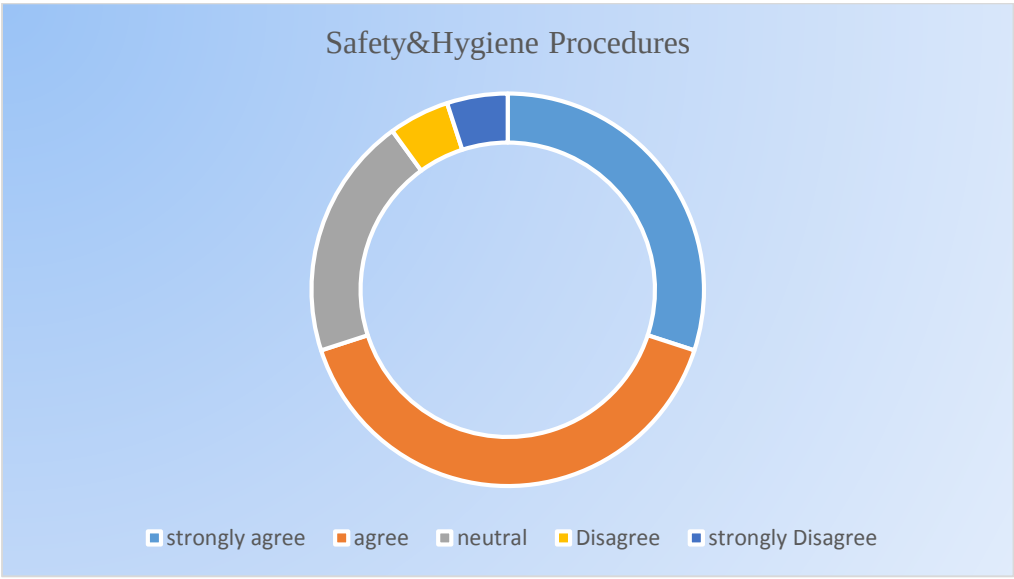
- Strongly Agree: 50%
- Agree: 30%
- Neutral: 10%
- Disagree: 5%
- Strongly Disagree: 5%



(Figure.37. Perceived Importance of Industrial hygiene &Safety Protocols -Survey Graph)

5.2.5.3. Awareness of Safety & hygiene Procedures:

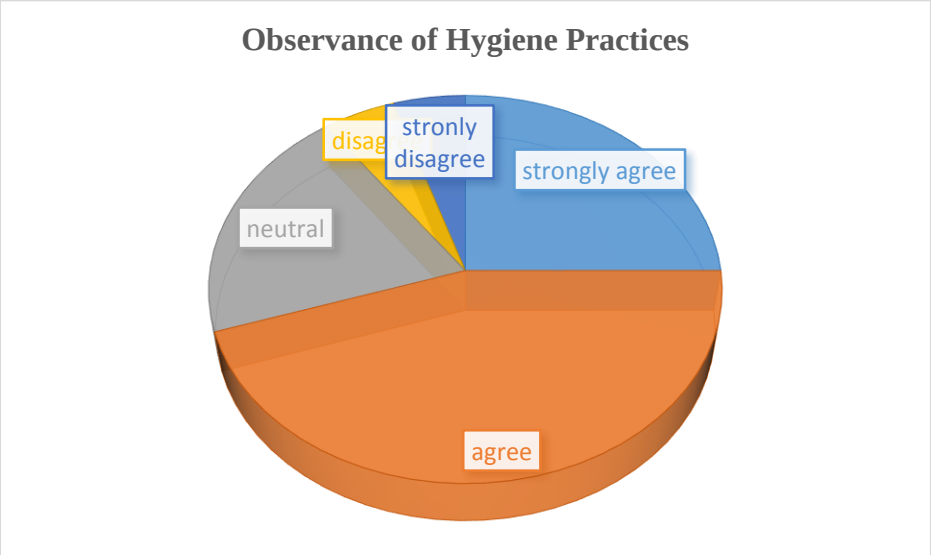
- Strongly Agree: 30%
- Agree: 40%
- Neutral: 20%
- Disagree: 5%
- Strongly Disagree: 5%



(Figure.38. Awareness of Safety & hygiene Procedures -Survey Graph)

5.2.5.4. Regular Observance of Hygiene Practices:

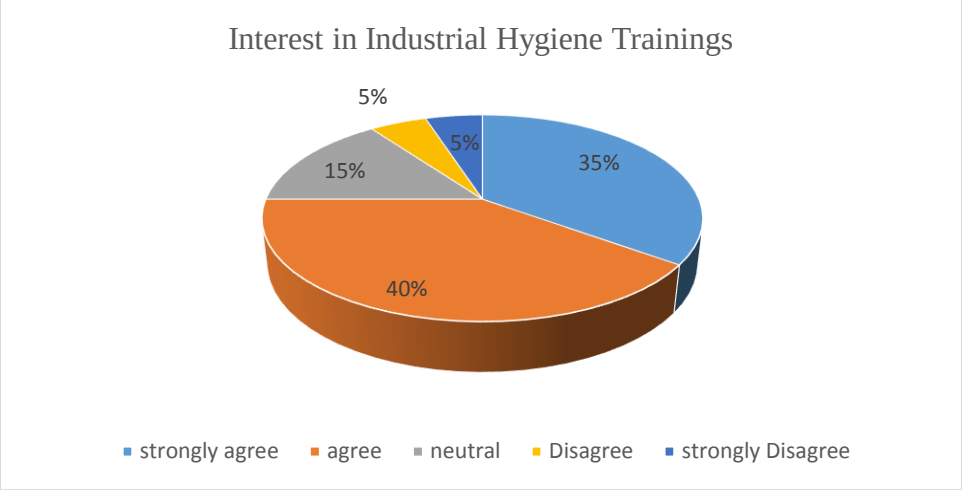
- Strongly Agree: 25%
- Agree: 45%
- Neutral: 20%
- Disagree: 5%
- Strongly Disagree: 5%



(Figure.39. Regular Observance of Hygiene Practices -Survey Graph)

5.2.5.5. Interest in Further Training:

- Strongly Agree: 35%
- Agree: 40%
- Neutral: 15%
- Disagree: 5%
- Strongly Disagree: 5%



(Figure.40. Interest in Further Training -Survey Graph)

5.2.5.6. Department Wise Respondents

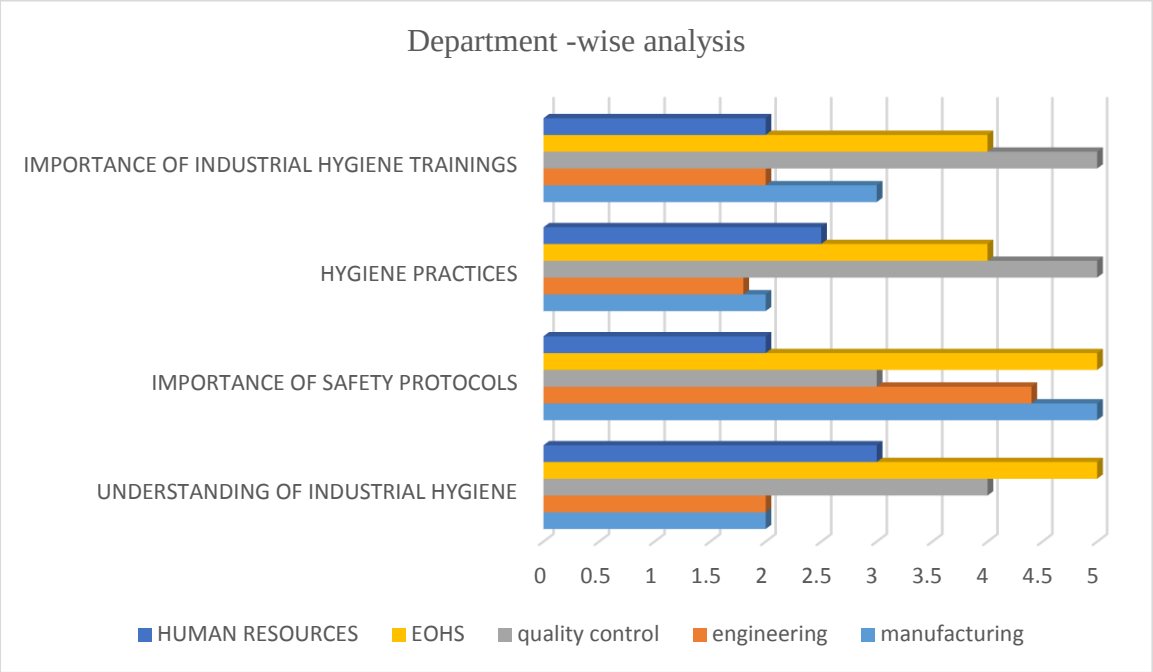
Table shows the department wise respondents

(Table.10. Department Wise Respondents)

S. No.	Range	No.of respondents	Percentage
1	Manufacturing	20	20
2	Engineering	20	20
3	Quality Control	20	20
4	EOHS - Environmental, Occupational Health and Safety	20	20
5	Human Resources	20	20
	Total	100	100

Interpretation: From the above survey, 20% of the respondents from manufacturing department and 20% of respondents from engineering, 20% respondents from quality control, 20% from EOHS & Human resources.

Graphical representation of department wise analysis



(Figure.41. Graphical representation of department wise analysis)

Data Analysis

- **Manufacturing: (20)**
  Higher agreement on the importance of safety protocols.
  Lower awareness of specific safety procedures.
- **Engineering: (20)**
  High level of understanding of industrial hygiene.
  Moderate interest in further training.
- **Quality Control: (20)**
  Strong observance of hygiene practices.
  Lower perceived importance of industrial hygiene.
- **EOHS (Environmental Occupational Health & Safety): (20)**
  High level of understanding of industrial hygiene and safety protocols
  Moderate interest trainings & hygiene practices
- **Human Resources: (20)**
  Lower agreement on hygiene trainings and safety protocols
  Moderate agreement on industrial hygiene practices.

5.2.5.7. Experience wise analysis of the respondents

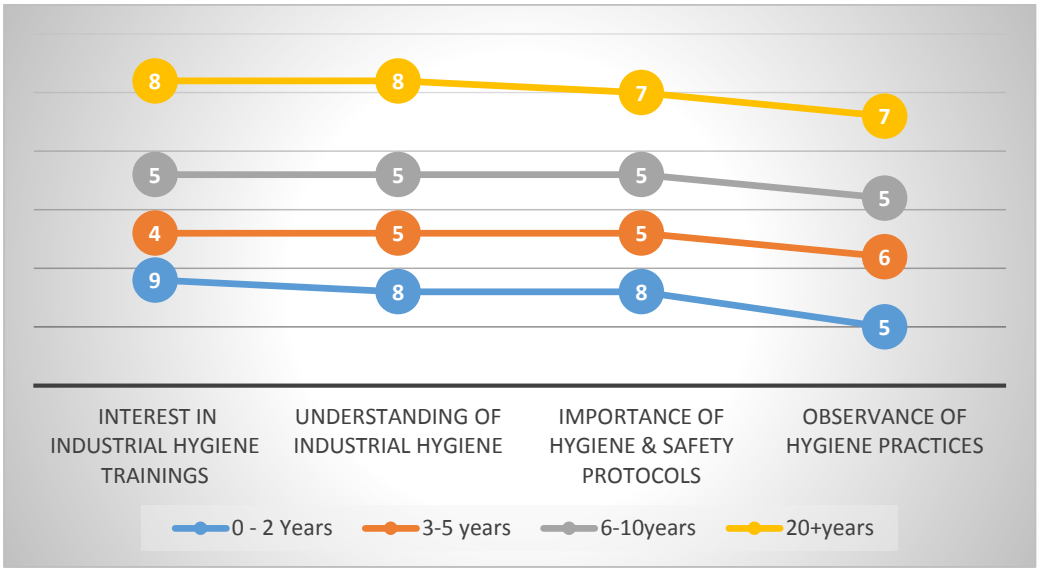
Table showing the Experience (in years) of the respondents

(Table.11. Experience wise analysis of the respondents)

S. No.	Range	No.of respondents	percentage
1	0-2 years	30	30
2	3-5 years	20	20
3	6-10 years	20	20
4	20+years	30	30
	Total	100	100

Interpretation: From the above table, 30% of the respondents have work experience of below 3 years, 20% of the respondents have work experience of 3-5years, and 20% of the respondents have work experience of 06-10 years,30% respondents have work experience of 20+ years.
Majority of the employees in the organization have a work experience of 0-2 and 20+ years

Graphical representation of experience level



(Figure.42. Graphical representation of experience level)

Data Analysis:

- **0-2 Years (New Hires): (30 members)**
  High interest in further training.
  Lower awareness of safety procedures.

- **3-5 years (mid hires) (20 members)**
  Moderate interest in understanding of industrial hygiene& protocols
  High interest in hygiene practices

- **6-10 Years (Mid-Level): (20 members)**
  High understanding of industrial hygiene.
  Strong agreement on the importance of safety protocols.

- **20+ Years (Veteran Employees) (30 members)**

  Consistently high observance of hygiene practices.
  Moderate interest in further training, possibly due to familiarity with existing protocols.

6. RESULTS

Exposure Monitoring Analysis

Chemical exposure monitoring in port (KSPL)
Benzene is well below the Permissible exposure limit, indicating suitable control measures concentration of Chemical Hydrogen sulphide exceeded the permissible limits.

Chemical exposure monitoring in the food industry
Iodine Exceeds the permissible exposure limit

Noise monitoring in port
At Dockside Operations, the level exceeds the recommended exposure limit, indicating a high risk of noise-induced hearing loss for workers in this area.
At container loading the average noise level in the loading docks area is 100dBA, which exceeded the acceptable limit, noticed temporary hearing loss in some workers while checking audio graph tests at health centre.

Noise monitoring in the food industry
Food Processing Areas: Because of the high noise levels generated by machinery and equipment in these regions, regular monitoring and hearing protection are required. Workers complain of headaches and prefer to communicate by shouting.
In Cleaning & Sanitation Areas, Noise levels are moderate, and appropriate personal protective equipment.

Heat stress exposure in port
At the Shipping Yard, Wet Blub Globe Thermometer (WBGT) heat index levels are high, and workers complained of dizziness and excessive sweating. Some workers had flushed skin.
At the Loading Area, the device indicated 31.1 degrees' centigrade temperature. Workers reported feeling extremely uncomfortable and thirsty.
One worker experienced nausea and vomiting.

Heat stress in food;
In the food processing area, workers are exposed to high temperatures, as indicated in Wet Blub Globe Thermometer (WBGT) levels, resulting in elevated heat stress, and they have profuse sweating (especially, workers who are standing and working near macro-ovens)

Ergonomic exposure monitoring in port
At loading docks, manually lifting heavy loads identified risk levels as high and also identified risk of musculoskeletal disorders (MSDs) with the help of ergonomic exposure assessment.

- At maintenance area for awkward posture: Identified high-risk tasks.
- At the storage area, due to repetitive motion, the exposure level is high, and people complain about pain in both legs.

Ergonomic exposure monitoring in food
At grinding and mixing areas, a high frequency of 8 hours of repetitive tasks with severely awkward postures indicates a higher risk.
At Good Manufacturing Practices (GMP) yard and conveyor belt operation zones, identified prolonged standing and repetitive hand movements indicate high-risk exposure with lower back and shoulder MSDs.

Employee questionnaire survey analysis:
A significant majority of employees across various departments indicated a strong understanding and appreciation of industrial hygiene.
Newer employees showed a keen interest in receiving more training about industrial hygiene, indicating a potential gap in initial training programs for new recruits.
Most respondents either agreed or strongly agreed on the importance of industrial hygiene.

Key theme points result:

- **Understanding of Industrial Hygiene:** 40% of employees strongly agreed
- **Importance of Industrial Hygiene &Safety Protocols** Strongly Agree: 50%
- **Awareness of Safety & and hygiene Procedures**: Only 30% of employees strongly agreed
- **Observance of Hygiene Practices** Only the least members Strongly agree, i.e.,25%
- **Interest in Further Training:** Moderately level of employees strongly agreed with 35%

Longitudinal Health Data Analysis
Analysis of health records from the Kakinada Seaports Limited (KSPL) industry indicated a correlation between exposure levels and the onset of specific health conditions, such as respiratory diseases and skin disorders.
Analysis of health records from the food industry indicated exposure levels and threshold limits are normal only for the onset of specific health conditions, such as musculoskeletal disorders.

Technological Advancements in Exposure Monitoring
The study identified emerging technologies, such as IoT-based monitoring systems and AI-powered risk assessment tools, that are set to revolutionize exposure monitoring practices.

Comparative Analysis Across Geographies
This study found significant variances in industrial hygiene practices and exposure monitoring standards between different geographical regions, influenced by regulatory frameworks, economic conditions, and cultural factors.

7. FINDINGS AND INTERPRETATION

7.1. Findings

High Overall Awareness and Importance
Most employees across various departments firmly understood and appreciated industrial hygiene. Most respondents either agreed or strongly agreed with its importance.

Experience Level Impact
Employees with longer tenure demonstrated higher adherence to hygiene practices, suggesting that experience correlates with increased awareness and implementation of safety protocols.

Training and Education
Newer employees showed a keen interest in receiving more training about industrial hygiene, indicating a potential gap in initial training programs for new hires.

Positive Safety Culture Indicators
The general trend of high awareness and the importance placed on industrial hygiene practices indicate a strong underlying safety culture within the industry.

7.2. Interpretations

Organizational Strength in Safety Awareness:
The high awareness and importance placed on industrial hygiene across all departments strongly indicates a robust safety culture. This is a significant strength for the organization, suggesting that safety is a shared value and priority.

Opportunity for Enhanced Training Programs
The interest shown by newer employees in further training presents an opportunity for the organization to enhance its on boarding and continuous education programs. Tailoring these programs to address specific gaps and reinforce safety practices can further strengthen the organization's commitment to workplace safety.

Role of Experience in Safety Practices
The correlation between years of experience and adherence to safety practices highlights the importance of experience in understanding and valuing industrial hygiene. This insight can be utilized in mentorship programs, where more experienced employees are crucial in training and guiding newer staff.

Uniform Safety Perceptions as a Strategic Advantage:

The lack of significant departmental differences in safety perceptions allows for implementation of uniform safety strategies across the organization. This can simplify training processes, policy implementation, and compliance monitoring.

Continued Monitoring and Feedback:
Regular surveys and feedback mechanisms should be maintained to continuously gauge employee perceptions and adapt safety strategies accordingly. This will help keep pace with changes in the workforce or operational procedures.

7.3. Implications for Enhancing Industrial Hygiene

Enhancing industrial hygiene in the food and port industries has significant implications, not only for the safety and health of the workers but also for the overall efficiency, productivity, and reputation of these sectors.

7.3.1. For the Food Industry

- Enhanced hygiene practices lead to reduced risk of contamination, resulting in safer food products and fewer foodborne illnesses.
- Stricter adherence to industrial hygiene standards ensures compliance with local and international food safety regulations, helping avoid legal issues and penalties.
- Higher hygiene standards can boost consumer confidence in the safety and quality of the food products, enhancing brand reputation.
- Better hygiene can lead to reduced product spoilage and waste, improving cost efficiency.
- A cleaner and safer working environment improves employee health, reduces absenteeism, and can enhance overall morale and productivity.
- Adhering to high hygiene standards can open up opportunities in more regulated markets, enabling business expansion.

7.3.2. For the Port Industry

- Improved hygiene practices reduce the risk of accidents and occupational diseases, ensuring a safer working environment for port workers.
- A cleaner and well-maintained port environment can lead to more efficient operations, with fewer delays and disruptions.
- Better waste management and pollution control measures help in complying with environmental regulations and reduce the ecological footprint of port activities.

- Ports are often close to urban areas; better industrial hygiene can minimize the impact of port operations on the surrounding community's health.
- Ports adhering to high industrial hygiene standards are better positioned to align with global best practices, attracting more international business.
- Ports with high hygiene and safety standards are more likely to be perceived as reliable and efficient, enhancing their competitiveness.

7.4. Overall Implications

- Both the food and port industries can experience economic gains through enhanced efficiency, reduced downtime, and broader market access.
- Enhanced hygiene standards are crucial for effectively managing risks and minimizing the likelihood of incidents that may result in substantial financial and reputational damage.
- Striving for better hygiene often drives innovation and the adoption of new technologies, leading to modernization and future-proofing of the industries.
- High standards in industrial hygiene can facilitate international trade and cooperation, as businesses and ports that adhere to these standards are more likely to be trusted partners in the global market.

8. DISCUSSION

The study identified key elements of industrial hygiene practices that are critical in manufacturing industries and highlighted the gap between knowledge and implementation in these settings.
Finding that advanced technological tools for monitoring environmental hazards are underutilized in small-scale industries sheds light on potential areas for intervention.
The study suggests the need for more stringent enforcement of industrial hygiene practices in the port sector.

Theoretical Contributions

Identified the impact of various industrial hygiene practices on worker health and safety. These models can be based on a thorough review and synthesis of existing literature.

Developed risk assessment methodologies that are more tailored to the port industry, mainly focusing on emerging risks due to new technologies or changing work environments.

Conducted empirical research to gather the data on occupational hazards and the effectiveness of existing safety practices.

Theoretical research into the effectiveness of various policies and regulations pertaining to industrial hygiene, and proposing new frameworks for policy development.

Advancing Educational Strategies: Researching and theorizing about the most effective ways to educate workers and managers about industrial hygiene

Practical Contributions

- **Field Studies and Data Collection:** Conduct extensive field studies to collect data on occupational health hazards, exposure levels monitoring and the effectiveness of current hygiene practices in food and port industries.

- **Intervention Studies:** Evaluated the effectiveness of various hygiene interventions in industrial settings. This could include new training programs, hygiene practices (ergonomic training)

- **Best Practice Case Studies:** Documented and analysed the case studies where industrial hygiene practices have led to significant improvements in health and safety, providing a roadmap for industries.

Community Engagement Projects: Engage with communities affected by industrial operations to understand their perspectives and develop practical solutions that address both worker and community health concerns. participated in mock drill.

Sustainability in Industrial Hygiene: Practical research into how industrial hygiene practices can be aligned with sustainability goals, focusing on waste reduction, minimizing environmental impact, and promoting long-term health.

Collaborations with Industry: Worked closely with industries to test and implement theoretical models or frameworks in real-world settings, providing valuable feedback loops for research.

9. LIMITATIONS OF THE STUDY

This study is focussed on two different industries in a specific region only. Which means the findings may not be generalized to other type of industries. However, the results might be applicable to similar industrial settings.

This study if focussed only on particular aspects of industrial hygiene depending on the type of industries selected.

In industrial settings, it is challenging to obtain complete data because employers and employees are hesitant to share sensitive information on health and safety past records due to confidentiality concerns, which might limit the in depth analysis by comparison.

The study is carried out using a mixed-methods approach. It was selected to gain a more thorough understanding of the working environment. However, the findings were based on a rather limited data set that was confined to only two industrial conditions; thus, strong inferences cannot be drawn from the data.

Exposure assessments are carried out within a limited timeframe, which may not accurately reflect long-term or chronic exposure levels and their impact.

As with most research, the study provides a snapshot in time and might not account for ongoing changes or future trends in industrial hygiene practices.

The rapidly evolving nature of industrial hygiene standards and practices might affect the study's long-term relevance, because of changes in relevant rules, regulations and Practices.

10. CONCLUSION

This study has comprehensively explored the multifaceted realm of industrial hygiene, emphasizing its critical role in safeguarding worker health and promoting a safe working environment. Through an in-depth analysis of exposure monitoring and employee survey analysis identified several key findings:

Validation of Industrial Hygiene Practices: It validates the effectiveness of comprehensive industrial hygiene programs in reducing workplace hazards and also influences policy-making by providing concrete data to support the enforcement of stricter industrial hygiene regulations and standards

Policy and regulatory impact: This finding provides empirical data that can be used to justify implementing and maintaining comprehensive industrial hygiene programs in various industrial settings.

Worker Well-being & **training:** This finding reinforces the critical role of thorough industrial hygiene practices in maintaining and enhancing worker safety. Organizations are more likely to adopt and invest in these programs, leading to safer work environments

Foundation for Future Research: This finding lays the groundwork for future research. It opens avenues for exploring the specific elements of industrial hygiene programs that are most effective, allowing for the development of more targeted and efficient strategies in various industrial sectors.

These findings underscore the evolving nature of industrial hygiene and its paramount importance in the context of port and food industries. The study has highlighted not only the traditional roles and responsibilities of industrial hygienists but also the emerging challenges, advanced and new technologies, and global trends.

Furthermore, this research has shed light on the need for advanced technologies to enhance the effectiveness of industrial hygiene practices. Integrating new technologies and innovations that can enhance industrial hygiene could include advanced monitoring systems and safer machinery for worker protection and health.

As we look to the future, it is evident that the field of industrial hygiene must continue to adapt and innovate. Future research should focus on Expanding Scope to Other Industries and Geographies and Technological Advancements in Industrial Hygiene, ensuring that industrial hygiene remains at the forefront of occupational health and safety. The journey towards a safer and healthier workplace is ongoing, and the findings from this study contribute a significant step forward in this vital endeavour.

In conclusion, this study reaffirms the importance of industrial hygiene as a cornerstone of occupational health. By continuing to evolve and address the challenges identified in this research, industrial hygiene can significantly contribute to the well-being of workers and the overall productivity and sustainability of industries worldwide.

11. RECOMMENDATIONS FOR FUTURE RESEARCH

- **Long-Term Health Impact Studies:** Future research should focus on the long-term health impacts of working in these industries, including chronic effects and mental health implications.
- **Automation and Emerging Technologies:** Investigate the impact of automation and emerging technologies on worker safety, job security, and operational efficiency in both sectors.
- **Focus on SMEs and Informal Sector:** Research should delve into the implementation of safety standards in small-scale operations and the informal sector, particularly in the food industry.
- **Environmental Sustainability and Worker Safety:** Explore the intersection between environmental sustainability efforts and worker safety, especially considering the effects of climate change on operational safety.
- **Gender-Specific Safety Challenges:** Studies focusing on gender-specific challenges and the need for tailored safety protocols are crucial, particularly in traditionally male-dominated sectors like ports.
- **Cultural and Regional Variations in Compliance:** Examine how cultural and regional differences within India influence the implementation and effectiveness of safety standards.
- **Policy Implementation Effectiveness:** Investigate the real-world effectiveness of existing policies, their implementation challenges, and case studies of successful safety standard applications.
- **Emergency Preparedness and Crisis Management:** Conduct in-depth research on emergency response preparedness, crisis management strategies, and learnings from past incidents in high-risk sectors.

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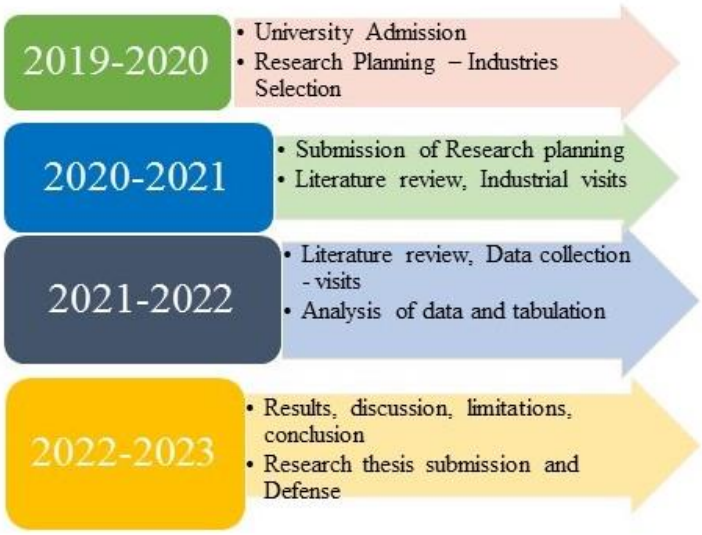
13. TIMELINE


2019-2020
• University Admission
• Research Planning – Industries Selection
2020-2021
• Submission of Research planning
• Literature review, Industrial visits
2021-2022
• Literature review, Data collection - visits
• Analysis of data and tabulation
2022-2023
• Results, discussion, limitations, conclusion
• Research thesis submission and Defense

14. LIST OF ACTIVITIES

- **Conducted Comprehensive Field Research**

  - Conducted comprehensive field research and gathered qualitative and quantitative data through observations, surveys, and interviews.

- **Reviewed and Analysed Academic and Industry-Specific Manuals**
  - Thoroughly reviewed and analysed academic and industry-specific manuals.

- **Implemented Exposure Monitoring Protocols**
  - Implemented exposure monitoring protocols in two distinct industries.

- **Collected and Analysed Data on Exposure Levels**
  - Collected and analysed data on various exposure levels and their effects.

- **Engaged in Specialized Industrial Training Programs**
  - Engaged in specialized industrial training programs to acquire practical skills and knowledge relevant to the field of study.

- **Conducted Ergonomic Assessment Training**

- **Participated in Medical Examinations**
  - Actively participated in medical examinations to gain insights into occupational health and safety.

- **Analysed Health Impacts in Occupational Environments**
  - Analysed the outcomes of these examinations to understand the health impacts of various occupational environments.

- **Participated in Academic Seminars and Conferences**
  - Participated in academic seminars and conferences to stay abreast of the latest research developments in the field.

- **Provided Mentorship to M. Tech-EOHS Students**
  - Provided academic and research guidance to M. Tech-EOHS students and assisted them in planning, developing, and executing their final project work**.**

- **Engaged in a Workshop on the Work Permit System and Workplace Safety**
  - Engaged in a workshop conducted by Jawaharlal Nehru Technological University and Andhra Pradesh Factories Department on Work Permit System and Workplace Safety.

- **Serving as a Guest Lecturer at JNTU**

- Serving as a Guest Lecturer in the Environmental Occupational Health & Safety department at Jawaharlal Nehru Technological University, Kakinada, Andhra Pradesh, India.

Delivering lectures and presentations on specialized topics within Environmental Occupational Health & Safety**.**

- **Presented Research Paper at the Healthy World Conference**
  - Presented the research paper on "Tobacco Causing Cancer" at the Healthy World Conference**.**

- **Submitted written papers for publication, adhering to the journal's guidelines.**

- **Participated in Courses at the University of Rome, 'Tor Vergata'**
  - Registered and participated in specific courses relevant to the Ph.D. research field conducted by the University of Rome, 'Tor Vergata.'

15. ANNEXURE 1

Title: "Industrial Hygiene in Practice: A Study on the Integration of Exposure Monitoring into Industrial Hygiene Practices in Food and Port Industries"

Employee Survey Questionnaire – Port Industry

Dear Participant,
Thank you for participating in this questionnaire. This survey is being conducted as part of a PhD research project on the importance of industrial hygiene in developing countries. This questionnaire aims to gather information about your knowledge, opinions, and experiences related to industrial hygiene practices in your workplace. Your responses will be kept private and exclusively used for research purposes.

Kindly respond to the following questions to the best of your capabilities. If a question does not apply to you or you are unsure, please leave it blank. There are no right or wrong answers, and your honest opinion is highly valued. The questionnaire is expected to need a time commitment of around 15 to 20 minutes for completion.

1. Please provide some general information about yourself:
   a) Name (Optional):
   b) Age:
   c) Gender:
   d) Job Title/Position:
   e) Years of Experience in your Current Role:

2. In which country do you work previously?

3. How would you rate your workplace's overall industrial hygiene practices?
   a) Excellent
   b) Good
   c) Average
   d) Poor
   e) Very Poor

4. What is the primary industry or sector of your workplace? (e.g., manufacturing, construction, healthcare, agriculture, etc.)

5. How familiar are you with the concept of industrial hygiene?
   a) Very familiar
   b) Somewhat familiar
   c) Not familiar

6. How important do you believe industrial hygiene practices in industries?
   a) Extremely important
   b) Very important
   c) Moderately important
   d) Slightly important
   e) Not important at all

7. What are the main reasons for implementing industrial hygiene practices in your workplace? (Select all that apply)
   a) Protecting employee health and safety
   b) Reducing workplace accidents and injuries
   c) Complying with legal and regulatory requirements
   d) Improving productivity and efficiency
   e) Enhancing company reputation and employee morale
   f) Other (please specify):

8. Have you received any training or education related to industrial hygiene?
   a) Yes, extensive training
   b) Yes, some training
   c) No, I haven't received any training

9. How well do you think your workplace implements industrial hygiene practices?
   a) Very well
   b) Moderately well
   c) Somewhat well
   d) Not well
   e) Not implemented at all

10. Are there any specific industrial hygiene-related hazards or concerns in your workplace? (e.g., chemical exposures, physical hazards, ergonomic issues, biological risks, etc.) Please describe briefly.

11. In your opinion, what are the significant challenges in implementing effective industrial hygiene practices in industries?

12. Have you observed any improvements in employee health and safety as a result of implementing industrial hygiene practices in your workplace?
   a) Yes, significant improvements
   b) Yes, some improvements
   c) No, no noticeable improvements
   d) Not sure

13. Do you believe that investing in industrial hygiene practices can have a beneficial impact on the overall development and growth of the industry?
   a) Yes, I firmly believe
   b) Yes, I somewhat believe
   c) Not sure
   d) No, I do not believe

14. What additional measures or support do you think, could enhance the implementation of industrial hygiene practices in industries?

15. Do you have any further thoughts or suggestions regarding industrial hygiene practices?

Thank you for your time and valuable input. Your participation is greatly appreciated. If you have any further questions or concerns, please feel free to contact.

16. PUBLICATION

TITLE OF THE MANUSCRIPT

"A Study on Assessment of Noise Exposure in the Port Industry: Implications for Occupational Health and Safety".

(Study is done under "Jawaharlal Nehru Technological University", Kakinada, Andhra Pradesh, India)

AUTHOR:

Name : Sankara Bhavani Budi

Guest Faculty, M. Tech Environmental, Occupational Health &Safety
Jawaharlal Nehru Technological University, Kakinada.

ABSTRACT

The workplace today is getting more complex, as exposure to chemical, physical, and biological substances at work poses an increasing range of hazards and risks. Industrial hygiene is "that science and art devoted to the anticipation, recognition, evaluation, and control of those environmental factors or stresses arising in or from the workplace". Exposure assessment is the heart of industrial hygiene initiatives, which serves as the foundation for all other functional elements, including medical surveillance, exposure monitoring, engineering controls, administrative controls, and hazardous materials management.

Ports are key hubs for worldwide trade, handling a wide range of cargo types with various machinery and equipment. The operational activities within these environments frequently generate high levels of noise, posing a potential hazard to the well-being of the workforce. The purpose of this study is to conduct a comprehensive assessment of noise exposure in the port industry at different locations and to propose appropriate mitigation strategies.

The methodology involves the use of sound level measurements using a sound level meter in various port environments. A thorough examination was carried out to identify specific locations for the purpose of conducting noise monitoring. The survey facilitated the quantitative assessment of noise exposure. Based on the findings of this study, necessary recommendations are proposed to minimize noise exposure and protect the well-being of port workers. The insights gained will not just assist port workers but will also contribute to a broader awareness of sustainable and responsible industrial practices.

Key words: Noise exposure, Port industry, Noise assessment, Noise control methods, Personal protective equipment.

INTRODUCTION

The port industry is essential for worldwide commerce, enabling the transportation of goods and promoting economic growth. However, operational characteristics of ports such as container handling, machinery, material handling, transportation activities, and other work areas generate a significant amount of noise. The exposure of port personnel to high levels of noise raises concerns about potential health and safety implications.

Addressing noise exposure in the port industry is essential for several reasons. The safety of the workforce comes first and foremost, and evaluating the extent of noise exposure is an important step in providing a safe working environment. Also, noise-induced health issues can have major economic consequences, such as increased healthcare expenditures and decreased worker productivity. Long-term exposure to elevated noise levels can cause stress, hearing loss, and other physiological and psychological health issues among workers. Because of the wide range of equipment and processes involved, the port industry poses particular challenges in monitoring and controlling noise exposure.

At every workplace, the exposure assessment approach has to be a cyclical process with continual improvements. This evaluation needs to look at any new information about the dose-

response relationship in the workplace, as well as the wide range of working conditions that are seen there now or by chance at the workplace level. The first step in assessing exposure will be to collect readily available information that is relatively easy to obtain.

The data obtained from the initial exposure assessments will then be utilized to prioritize follow-up control and information-gathering efforts. As a result, the allocated resources have to be focused on specific exposures, with a priority assigned to the potential health risk. This way, the exposures are better understood and controlled; they will drop in priority, and therefore the industrial hygienist will move on to the next cycle of the plan, addressing the next tier of priority exposures.

The assessment method involves the monitoring and evaluation of noise exposure in the workplace by an industrial hygienist from the Environment, Health, and Safety (EHS) department.

The industrial hygienist is responsible for conducting two types of assessments:

- The preliminary noise survey is conducted as an in-depth assessment of noise exposure. It includes a "walk-through" survey of the facility with a sound-level meter. Variations in noise levels due to the operation of noise-generating equipment or machinery are taken into consideration.
- The detailed noise survey is conducted in cases where the preliminary survey data suggests the need for specific monitoring. This survey uses a sound level meter to obtain precise information on the noise levels at each individual workplace. That involves an assessment of the level of employee exposure over the course of an 8-hour workday and determining the specific areas that should be identified as noise-risk areas and require the use of hearing protection.

Objectives of this study:

- Identification and assessment of noise levels across different port operational zones
- Evaluation of the potential health effects of noise exposure on port personnel.
- Propose recommendations to minimize noise exposure in the port environment.

This study's findings contribute by giving useful information that may be used to develop and implement specific measures aimed at reducing noise levels and safeguarding the well-being of port workers.

LITERATURE STUDY

The port industry is an important part of global trade since it enables the transportation of goods and commodities around the world. However, port operations can generate significant levels of noise, posing risks to the health and well-being of workers. The purpose of this literature review is to thoroughly analyse existing research on noise exposure in the port industry.

A diverse range of activities, such as cargo handling, ship operations, and machinery usage, result in elevated noise levels in the port industry. Port workers have been recognized as a high-risk group for occupational noise exposure in multiple studies (Jeebhay et al., 2012; Themann

& Masterson, 2019). Understanding noise sources and levels is crucial to establishing effective noise management strategies. Smith et al. (2018) revealed that port workers are frequently exposed to noise levels that exceed recommended occupational limits. This exposure has been linked to a variety of sources, including container handling equipment, ship engines, and vehicle traffic at port facilities (Chang et al., 2019). The adverse effects of prolonged exposure to elevated noise levels are well-documented, ranging from hearing loss to stress-related disorders (Kang et al., 2020).

The adverse health effects of noise exposure in the port industry have become a growing concern. Davis and Qiu's (2021) study found a link between occupational noise exposure in ports and a higher risk of cardiovascular disease among workers. Furthermore, Li et al. (2017) found that noise had a psychological impact on port workers, with increased stress levels and decreased job satisfaction.

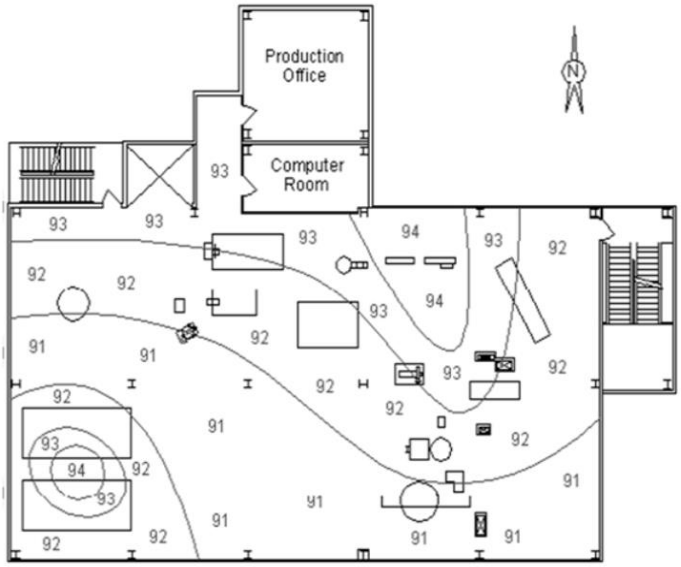
Multiple techniques are used for the evaluation of noise exposure within the port sector. The use of sound level meters is widely employed to assess the noise levels in various port areas. EU-OSHA (2020). Various control measures are established and used to manage noise exposure in the port industry. Engineering controls, administrative measures, and personal protective equipment are among these. The effectiveness of these measures varies depending on the port environment and activities (Pinto et al., 2015; Themann & Masterson, 2019).

National and international regulatory bodies have established legal frameworks and standards to address noise exposure in the workplace, including ports. Compliance with those requirements is essential for protecting port workers' health and safety. However, challenges exist in effectively implementing and enforcing those requirements (Hsu et al., 2018; EU-OSHA, 2020). The American Conference of Governmental Industrial Hygienists (ACGIH) is one such widely recognized organization that plays a crucial role in developing standards to safeguard workers from occupational risks. The ACGIH provides comprehensive recommendations that cover all areas of industrial hygiene, including noise exposure, acknowledging its importance in safeguarding worker health.

METHODOLOGY

The methodology for assessment was formulated based on international guidelines provided by the American Conference of Governmental Industrial Hygienists (ACGIH), USA. A sound level meter and a noise contour map were used to conduct a quantitative assessment of noise exposure. Based on the assessments, the necessary recommendations for noise exposure control have been provided.

Every noise map is the outcome of a noise model that is based on several fundamental inputs, including a list of all the noise sources and their locations and a model of the area under investigation.



Noise contour map (Figure 1)

The monitoring was carried out using an integrated sound level meter. Prior to and subsequent to the readings, the sound level meter was properly calibrated using a calibrator. A company based in the United States of America called Quest Technologies manufactured the equipment. Sampling was carried out on an area-by-area basis at selected workplaces.

Sound Level Meter (Figure 2)

The noise measurement results were compared to the Permissible Exposure Limits (PELs) stated in the Andhra Pradesh Factories Rules 1950 and the Threshold Limit Values (TLV) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) for an 8-hour exposure to noise, which were 90 dB (A) and 85 dB (A), respectively.

Different noise sources at port industry:

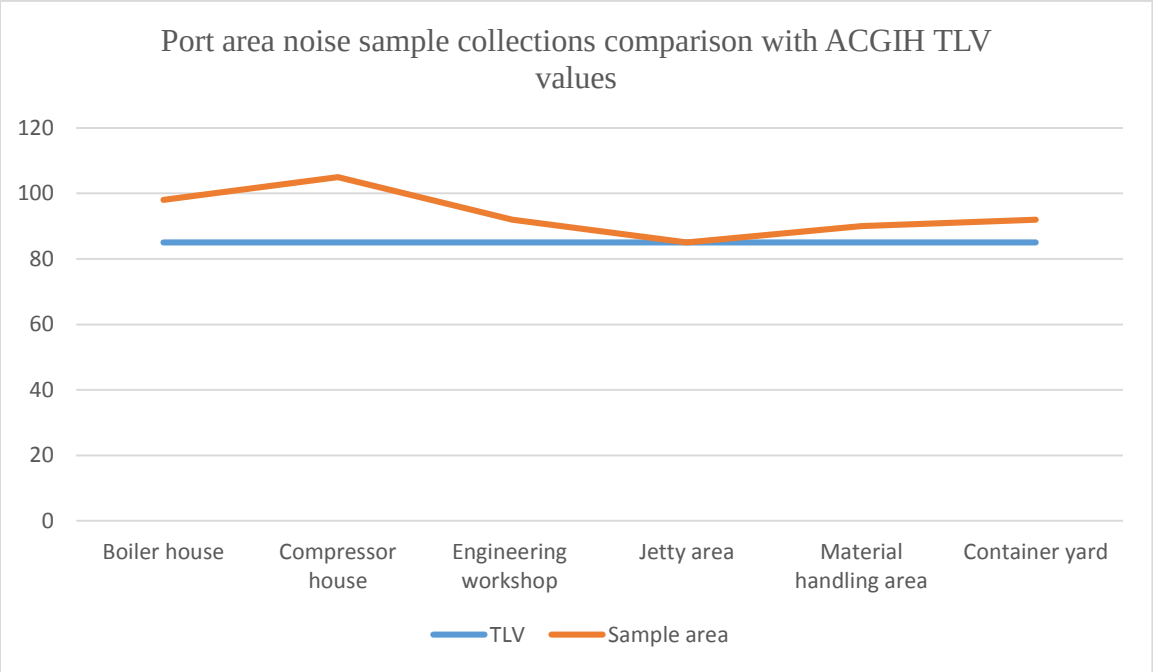
- Internal port traffic;
- Port related external traffic
- Cargo handling
- Boiler house
- Engineering work shop
- Container yard
- Material handling area
- Compressor house
- Jetty area

RESULTS

Results of high noise sources at port industry in comparison with ACGIH threshold limit values: (Table 1)

S.no	Location	Minimum (dB)	Maximum (dB)	Average (dB)	TLV	Comments
1	Boiler house	88	100	98	85	Above TLV
2	Compressor house	99	108	105	85	Above TLV
3	Engineering work shop	88	96	92	85	Above TLV
4	Jetty area	72	88	85	85	Equal to TLV
5	Material handling area	88	92	90	85	Above TLV
6	Container yard	90	95	92	85	Above TLV

Graphical representation of Noise levels



SPECIFIC RECOMMENDATIONS FOR CONTROL OF NOISE EXPOSURE:

To avoid the harmful health consequences of excessive noise exposure in those mentioned areas, the following recommendations are proposed for implementation:

- When noise reverberates around a room, the only method for reducing it is by absorption. Absorption panels and baffles absorb a high percentage of sound energy and dissipate it as kinetic heat energy. The maximum noise reduction potential is 4 to 6 decibels, resulting in a 20 to 30% reduction in noise intensity.
- Treat the wall nearest to the source of the noise by using the acoustic foam panels. The maximum sound reduction ranges from 2 to 6 decibels. This economical solution reduces noise levels by 10 to 30%.
- Construct a barrier or shield, which can be used as "instant walls" that isolate noisy machinery. The most effective method of preventing single-source noise from echoing around the room is to build an acoustic barrier around the machine that blocks the sound energy.
- Build an acoustic enclosure around the machine to contain noise at the source. The maximum noise reduction potential is between 20 and 30 dB.

RECOMMENDATIONS FOR NOISE EXPOSURE CONTROL IN GENERAL:

Excessive noise is one of the most common workplace hazards in industries. Prolonged noise exposure in the workplace can lead to impaired verbal communication, fatigue, lower productivity, and work-related hearing loss.

The following are the general recommendations for controlling noise exposure:

- Ensure that workers follow safety procedures and wear appropriate personal protective equipment while performing their duties.
- Workers should be trained on the importance of personal protective equipment, as well as its proper use, storage, and maintenance. It should be stated that the majority of hearing-protective equipment provides only about 15 dB of protection to workers.
- It is recommended that suitable hearing protection equipment selection be based on the attenuation rates provided by the manufacturer of personal protective equipment (PPE).
- Workers exposed to noise levels exceeding 100 dB may suffer hearing loss even though they wear hearing protection regularly. As a result, the length of exposure should be reduced to the shortest amount possible for such workers to avoid overexposure to noise.
- Workers must undergo an audiometric evaluation annually to detect early signs of hearing impairment.

DISCUSSION

The assessment of noise exposure at various locations has provided valuable insights into the potential risks and effects of occupational noise exposure. This study revealed significant variations in noise levels across different locations within the port. High noise levels have been observed in the boiler house and compressor house areas, highlighting the need for remedial measures in those specific areas.

This study assessed the extent to which noise levels met existing regulatory limitations. It is essential to determine whether the noise levels documented are in compliance with the relevant occupational safety and health regulations. In order to maintain noise exposure within acceptable levels, noncompliance might necessitate establishing and carrying out specific strategies. To effectively mitigate noise exposure, it is recommended to use a comprehensive approach that integrates engineering controls, administrative measures, and the use of personal protective equipment (PPE). Engineering controls may involve the implementation of noise barriers, the enclosure of noisy machinery, and regular maintenance to reduce equipment-related noise emissions. Administrative measures include several strategies, such as the establishment of specified quiet zones, the adoption of rotating work schedules, and the provision of employee training programs to promote awareness about the risks of noise exposure.

Training programs should prioritize providing information to employees concerning the potential hazards and risks related to noise exposure, the proper use of personal protective equipment (PPE), and the significance of adhering to safety protocols. These programs have the potential to enable workers to actively participate in minimizing their own occupational noise exposure. By prioritizing the reduction of noise exposure, the industry can enhance the well-being of its workers, improve overall productivity, and ensure regulatory compliance.

LIMITATIONS

While this study on the assessment of noise exposure at various locations in the port industry provides useful information, it is essential to acknowledge its limitations.

- The findings of this study may not be universally applicable to all port facilities because noise levels vary depending on the specific activities, equipment, and infrastructure present at each facility.
- The scope of the study is limited to specific places within the port facility, and the findings may not be fully indicative of the different working conditions seen throughout the industry.
- Noise levels in the port industry vary with operational schedules, maintenance activities, and cargo volume. Since the data was collected over a particular period of time, this study may not fully represent those variations.
- The study's findings may be influenced by changes in noise rules, regulations, or industry practices. Changes in rules, regulations, or industry standards that occur after this study could have an impact on the applicability of the findings.

CONCLUSION

This study focuses on the evaluation of industrial noise exposure, aiming to provide insights into the complicated challenges associated with high levels of noise in work environments. The findings of this study emphasize the significance of giving priority to initiatives aimed at promoting occupational health and safety. The noise levels observed in this study, specifically within the compressor house (105 dB) and boiler area (98 dB), highlight the immediate need for specific measures to mitigate the impact on workers.

One significant finding is the identification of high-risk zones within industrial environments where noise exposure exceeds the recommended thresholds. The use of engineering controls, such as the implementation of effective guarding, closed enclosures, and system redesign, has the potential to significantly mitigate noise-related health hazards among workers in those identified zones.

This study further emphasizes the need for personal protective equipment (PPE) to reduce exposure. It is important to realize that PPE alone is not a comprehensive solution. Combining it with engineering controls and administrative measures like rotating work shifts or implementing quiet zones will contribute to a stronger and effective noise management strategy. As industries evolve, it is essential that regulatory bodies update noise exposure standards. By implementing evidence-based methodologies and adopting innovative

approaches, safer and healthier industrial environments can be created, thereby safeguarding the well-being of the workforce and promoting sustainable industrial practices.

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