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Risk Assessment and Occupational Health Concerns in Wastewater Effluent Treatment Plants

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ABSTRACT

Dye-containing wastewater poses a serious risk to human health and the environment because the textile industry generates a lot of wastewater that is highly coloured and contains a number of persistent pollutants. The dyeing and printing industries rely significantly on effluent treatment plants to lessen the environmental damage caused by the discharge of wastewater containing dyes, chemicals, and other pollutants. Although they are the most dangerous sectors of the economy, they promote environmentally friendly behaviour and ensure that laws are observed. Effluent Treatment Plants (ETPs) must conduct risk assessments in order to identify and mitigate potential hazards, preserve the environment, and comply with regulatory standards. A summary of the need for and assessment of ETP risk assessment was provided. A thorough analysis was conducted to determine the possible health hazards associated with the wastewater treatment plant. The most important factors that could affect workers while they are at work are listed in this study. To increase workers' awareness in the workplace, the main categories of hazards and safety performance were compiled. Techniques for risk-control were identified and explained in detail in an attempt to lower accidents in wastewater treatment plants.

KEY WORDS: Waste water, Effluent Treatment Plants, risk assessment, health hazard, safety performance.

The fast rise in hazardous dye wastewater produced by different industries remains a major environmental and public health concern, presenting a formidable obstacle to the current conventional water treatment systems (Dutta et al., 2021). In many nations, the textile industry contributes significantly to environmental pollution and the global economy. (Olisah and others. 2021). The textile industry produces a lot of wastewater that is highly colored and contains a variety of persistent pollutants, making dye-containing wastewater a major environmental and health hazard (Almroth et al., 2021) Since wastewater treatment is a necessary social function, it was added to the list of Sustainable Development Goals. In order to reduce environmental harm brought on by the discharge of wastewater containing dyes, chemicals, and other pollutants, the dyeing and printing industries depend heavily on effluent treatment plants (ETPs). They encourage sustainable practices and make sure that environmental regulations are followed (Adane et al., 2021) The necessity of ETPs in this sector is explained in greater detail below:

Environmental Concerns:

- Water Pollution:
  The substantial volumes of wastewater produced by textile dyeing and printing operations contain chemicals, dyes, and other pollutants that can contaminate water sources and endanger aquatic life (Adane et al., 2021).
- Toxic Chemicals:
  The industry uses a variety of chemicals, some of which are hazardous to human health and ecosystems because they can linger in the environment.
- Dye Residues:
  Some dyes are not completely absorbed during the dyeing process, and the leftover dye residues in wastewater can lead to discoloration and other issues with the quality of the water (Azanaw et al., 2022)

Effluent Treatment Plants (ETPs) have the following advantages:

- Environmental Protection: By eliminating contaminants from wastewater, ETPs lessen the negative effects of textile industry discharge on the environment and safeguard water supplies.

- Regulation Compliance: ETPs assist businesses in adhering to environmental rules and wastewater discharge guidelines, preventing fines and guaranteeing legal compliance.
- Resource conservation: Reusing treated wastewater for non-potable uses, such as irrigation, lowers the need for fresh water and saves money.
- Sustainable Development: ETPs support a healthier environment and sustainable development by reducing pollution and encouraging resource efficiency.
- Cost Savings: By lowering water usage, cutting down on waste disposal expenses, and averting possible fines for non-compliance, ETPs can ultimately result in cost savings.
- Better Water Quality: ETPs make sure that the industry's water discharge satisfies regulations, preventing pollution and safeguarding the public's health (Adane et al., 2021, Azanaw et al., 2022).

Risk assessment for Effluent Treatment Plants (ETPs) is essential for detecting and reducing possible risks in order to maintain safe operations, safeguard the environment, and adhere to legal requirements. An effluent treatment plant's (ETP) risk assessment finds possible risks, evaluates them, and puts safety precautions in place to safeguard the public, employees, and environment (Tuser and Oulehlova, 2021). During the water treatment process, numerous chemical compositions are released; even low concentrations of these compositions can have an impact on plant occupants' health. Numerous employees at wastewater treatment facilities experience headaches, nausea, dizziness, anxiety, stress, and unconsciousness. Because the workers are exposed to inhalation, a health risk assessment program must be implemented to examine them (Zhou et al., 2016; Drewnowski et al.,2018). Among the industrial sector's most hazardous areas are wastewater treatment plants (WWTPs). Every year, a large number of workers pass away as a result of a lack of occupational health awareness. Safety performance has become crucial for various industrial projects. Concerning the general conduct of employees on the job site, safety performance is typically assessed through system management and the identification of potential health risks (Dannoun and Nouban, 2021).

The following summarizes the necessity of ETP risk assessment:

1. Safety and Health:
- Identifying potential hazards: identifying potential hazards in the ETP, such as chemical exposure, trips, falls, and exposure to hazardous gases, is made easier with the aid of risk assessment.
- Protection of Workers: By being aware of these risks, workers can be shielded from harm by putting in place the proper safety protocols.
- Preparedness for Emergencies: Risk assessment guides the creation of emergency response plans to effectively manage situations.

2. Environmental Protection:
- Pollution Prevention: ETPs are made to clean wastewater and stop pollution, but how well they work and stop unintentional pollution releases depends on risk assessment.
- Environmental Compliance: Risk assessment reduces the possibility of fines or legal action by demonstrating adherence to environmental standards and regulations.

3. Operational Efficiency:
- Process Optimization: Risk assessment can aid in the optimization of ETP processes by spotting possible issues, which will increase productivity and cut expenses.
- Preventative Maintenance: By identifying areas that require preventative maintenance, risk assessment can lower the likelihood of equipment failure and downtime.

4. Mandatory Requirements for Legal and Regulatory Compliance:
- Mandatory requirements: Risk assessment is a legal requirement for ETPs in many jurisdictions, especially those that handle hazardous materials.
- Exhibiting Due Diligence: By carrying out a comprehensive risk assessment, the ETP operator shows that they are taking appropriate measures to guarantee the facility's safety and environmental protection (Loj-Pilch et al., 2019)

EVALUATING THE RISK OF AN INCIDENT.

Identifying the nature of risk is necessary for risk assessment and control in traditional projects. Several general steps must be taken to comprehend the risks, as outlined below (Han et al. 2008):

- Determining the type of risk,
- analysing its impact,
- assessing its degree,
- responding and making decisions, and
- keeping an eye out for potential dangers.

RISK ASSESSMENT & HAZARD IDENTIFICATION

1. RISK ASSESSMENT: Risk assessment is the process of identifying possible risks and analysing the possible outcomes in the event that a risk materializes. Previous accident analyses at similar projects, prior rulings, and knowledge of risk analysis, particularly accident analysis, are the foundations upon which risk assessment is conducted.
2. HAZARD IDENTIFICATION: The first step in a risk assessment process is hazard identification. Different types of hazards are identified as a result of a hazard analysis. Potential conditions that exist or do not (probability is 1 or 0) are called hazards. It may exist alone or in combination with other risks (also referred to as events and conditions) to result in a real accident or malfunction. The goal of the Hazard Identification and Risk Assessment method is to first identify the primary hazardous material and then attempt to lessen its impact. We will employ a variety of risk assessment techniques for this purpose, taking into account the consequences of the hazards and examining every procedure that is used during handling.
3. RISK AND OCCUPATIONAL HEALTH
   The following operations present significant health risks to the site's employees:

- air pollution caused by DG set operations.
- production of noise from blower operations and DG sets.
- fuel and chemical handling. In addition to the storage of chemicals, the planned expansion and upgrade of CETP tanks may also give rise to other unintended consequences, such as failures in storage vessels for flammable liquids like HSD.

4. INSTRUMENTS AND EQUIPMENTS HANDLING
   The workforce of Treatment plant is anticipated to handle following instruments/equipment:

- Laboratory equipment.
- Metering and measurement tools.
- Machines for lifting and disposing of waste.
- Handheld mechanical instruments.
- Both blowers and pumps.

PRINCIPAL TYPES OF RISK IN ETP:

The wastewater treatment plant has a lot of factors that need to be identified and taken into account at work. Because they are related to health and safety, these factors are significant. They can be addressed by determining the risks, evaluating the hazards, and adhering to rules and regulations (Islam and Ryan, 2015; Ramesh et al. 2017).

1. Toxic Dyes: In nature, textile dyes, especially synthetic ones, can accumulate in the environment due to their persistence and difficulty in degrading.
   Effects:

- Water Pollution: Dyes have an adverse effect on aquatic ecosystems by discolouring water bodies, reducing light penetration, and impeding photosynthesis.
- Toxicity: Through the food chain, certain dyes can harm aquatic life and endanger human health.
  Bioaccumulation: Long-term health effects may result from dyes building up in aquatic organisms' tissues (Tohamy et al., 2022; Panhwar et al., 2024)

2. Heavy Metals:

Nature: Textile dye pigments are made from heavy metals such as arsenic, chromium, cadmium, mercury, and lead.
Effects:

- Toxicology: Heavy metals are extremely harmful and can lead to major health concerns, such as cancer, problems with development, and problems with reproduction.
- Persistence: Because heavy metals are not biodegradable, they can contaminate soil and water for extended periods of time.
- Bioaccumulation: When heavy metals build up in an organism's tissues, it can cause bioaccumulation in the food chain.

3. Aromatic Compounds:
   Characteristics: Aromatic compounds are ring-shaped organic molecules, some of which are carcinogenic or toxic.
   Effects:

- Toxicity: Humans and aquatic life may be poisoned by certain aromatic compounds.
- Persistence: certain aromatic compounds have the ability to bio accumulate and remain persistent in the environment.

4. Other Pollutants:
   Suspended Solids: High concentrations of suspended solids in textile wastewater can degrade water quality and endanger aquatic life.
   Chemical Oxygen Demand (COD): The presence of organic matter in wastewater can raise the chemical oxygen demand (COD), which indicates that more oxygen is needed to break down the organic matter. This could result in oxygen depletion in water bodies.
   Additional Chemicals: Other dyeing-related chemicals, including salts, auxiliary chemicals, and surfactants, may also be present in textile wastewater and can contaminate water supplies (Tohamy et al., 2022; Panhwar et al., 2024)

FACTORS AFFECTING SAFETY PERFORMANCE

A number of factors, each linked to risk, can have an impact on employees while they are on the job. To determine the degree of the resulting risk, these factors typically need to be examined and assessed (Pinto et al. (2011). These variables typically differ from one project to the next. It was observed that a variety of factors, including a lack of health and safety awareness in the workplace, a budget that does not support the safety plan, a lack of training programs, supervision, and awareness for the various tasks (i.e. e. plumbing, electrical, and maintenance), a lack of knowledge about standards, and tasks that are assigned that change frequently. A few factors gathered from various earlier studies are described in Table 1 (Loosemore et al. 2012; Cheng and colleagues. Sertyesilisik et al. (2010).

S.No.	Factor	S.No.	Factor
1	Poor work and safety organization	9	Workers are not familiarized with machine and equipment
2	10 Limited budgets for health and safety measures	10	Workers are much more responsible
3	Lack of coordination	11	Inadequate training and fatigue of practitioners
4	Economic and time pressure	12	Bad equipment selection, use or inspection
5	Lack of information about hazards, accidents	13	Poor safety awareness of top management and project managers
6	Poor communications both internal and external	14	Lack of prevention/protection equipment

7	7 Poor involvement of workers in safety matters	15	Construction jobs can be far apart
8	Constantly changing worksite	16	Workers face long term health risks from the stress

Table 1 – General factors affecting the performance of workers (Dannoun and Nouban, 2021)

REDUCTION OF RISK OCCURRENCES.

Occupational health services must be provided to WWTP workers, and a health monitoring program must be conducted on a regular basis, as Tiwari (2008) noted in their study. Additionally, a regular awareness program should be conducted to share safety working procedures and the need for workers to wear protective gear. In order for employers to provide workers with the right assistance when they are hurt on the job or become ill, health and safety-first aid must be prepared appropriately in accordance with regulations, mandatory list items, and employer requirements (Shafik et al. 2019).

In order to lower the risk incidence in wastewater treatment plants, Spelman and Welsh (2017) recommend the following guidelines:

• Emphasizing safe work practices and warning labels about OSHA requirements;

• Having a safety engineer conduct a safety training program for employees;

• Conducting routine audits of the district spaces in the workplace;

• Offering a first aid training program.

According to OSHA (2016), there are numerous steps involved in conducting a hazard inspection. Workplace hazards can be characterized as stations, equipment, or maintenance that have been neglected and are out of control. Before beginning work, the staff must undergo an inspection; in order to set up this phase, certain documents must be taken, including:

• Performing an inspection of all work-related locations and identifying potential sources of hazards;

• Examining all activities carried out on the job site, in storage, and in warehousing, including those involving tools and small machinery that may affect workers;

• Creating checklists for each task or mission in the work, such as electrical work, equipment operation, fire safety, worker ergonomic issues, slip and fall hazards, and machine maintenance;

• Before altering the work plan, an assessment must be conducted to prevent danger.

Sulojeva and colleagues (2011) concluded that providing protective clothing, respirators, gas masks, safety goggles, gloves, safety boots, and safety strips to employees can eliminate or lower the risks associated with hazards in wastewater treatment plants.

CONCLUSION

The fast rise in hazardous dye wastewater produced by different industries remains a major environmental and public health concern, presenting need for waste water treatment plants that are crucial for public health and environmental protection, removing harmful contaminants and preventing waterborne diseases, while also posing occupational hazards to workers. The wastewater treatment plant's potential health risks were identified through an extensive review. This study lists the most significant variables that may have an impact on employees while they are at work. The primary types of hazards and safety performance were compiled to raise workers' awareness in the workplace. In an effort to reduce accidents in wastewater treatment plants, risk-control techniques were identified and thoroughly explained.

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