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Original Research

Assessment of Azo Dye in Textile Wastewater and Examination of the Fire Safety Measures in Garment Industries in Tirupur District, India

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Abstract

A safe and healthy workplace is considered to be a right for any worker/employee. The proper functioning of the Occupational Safety and Health (OHS) management system especially in the garment industry will revitalize the workers as well as increase the Indian economy. In Tamil Nadu, especially in Tirupur, there are more than 200 garment industries where approximately more than 41,200 workers are working in the spinning, weaving, ginning, garment, and dyeing sector of the garment industry. The waste material generated from the garment industry contains azo dye which could also cause health impacts on the workers which might include cancers, skin diseases, and respiratory problems. The development of the garment industry not only relies on its technical upsurge but also depends on a systematically organized occupational health and safety by its management. Among safety hazards, fire accidents and exposure to hazardous dye in the industries are the primary sources of accident and health impacts in textile industries, and preventing them would be the first and foremost criterion to run the business successfully. Hence, the present study aimed to investigate the health hazards due to azo dye discharge and assess the fire safety measures among people working in the garment industries from Tirupur district, Tamil Nadu, India. The results of the present study depicted the effect of azo dye on health aspects and the importance of fire safety in the garment industry. In conclusion, it is hoped that this study can contribute to support measures for the prevention, promotion, protection, and rehabilitation of the health of workers from garment industries.

Keywords: fire safety measures, Occupational Safety and Health (OHS), workers safety, wastewater chemical, azo dye

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Introduction

In India, the textile sector produces close to 14% of all industrial output. In India, there are 2100 bleaching and dyeing industries and roughly 10,000 garment producers. India's textile sector is generally organized into clusters, with about 70 of these clusters contributing 80% of the nation's textile output. Tirupur and Karur in Tamil Nadu, Ludhiana in Punjab, and Surat in Gujarat are the places where more textile industries are present. Through its contribution to GDP, employment, the exchange rate, exports, total production, etc., the textile sector is playing a critical role in the economic development of India [1]. The garment industries are highly competitive industry but few minor cost-saving hacks especially the lack of safety measures in our country pose a major impact on the health and safety of the workers [2]. In India, Tamil Nadu is the major sector for the garment industry composed of 1371 businesses related to this industry and approximately 38,461 workers are working under these sectors (spinning, weaving, ginning, garment, and dyeing) [3]. Tirupur is one of the districts in Tamil Nadu and is an overriding contestant in the knitting garment sector. The apparel exporters in Tirupur mostly produce and export knitted garments and the share of the woven garment is insignificant when compared with knitted garment production and exports. Tirupur is also known as the T-shirt city.

The textile printing industry releases large amounts of wastewater with toxic chemicals from various processing units as unwanted materials [4]. Chemicals are emitted together with effluent from various textile production machines. Some companies release untreated wastewater into the environment because they lack a wastewater treatment facility. The environment is negatively affected by the released untreated wastewater, which has an impact on its ecological quality [5]. The textile business raises many safety and health concerns. From the wastewater, employees in the textile sector are exposed to a variety of chemicals, particularly those working in the dyeing, printing, and finishing processes. In the fabric industry, benzidine-based chemicals are utilized as optical brighteners, solvents, fixatives, crease-resistance agents that release formaldehyde, flame retardants made of organophosphorus and organobromine compounds, and antibacterial agents. Formaldehyde exposure has been linked in studies to leukemia, brain cancer, nasal and lung cancer, as well as other potentially lethal diseases. Long-term exposure to formaldehyde may cause eczema and breathing problems. Both inhaling the chemicals as well as coming in contact with them on the skin can have major health consequences. One study found a modest link between working in the textile business and acquiring oesophageal cancer, whereas another found that textile workers had a significant chance of developing stomach cancer [6].

The development of the garment industry not only relies on its technical upsurge but also depends on a systematically organized occupational health and safety (OHS) by its management. It was identified that only a few industries have an OHS management system, out of which only a few industries are strongly implementing, maintaining, and following the OHS management system, particularly in fire safety. The main framework of OHS management is to protect and safeguard the workers from any injuries or ailments caused in their workplace as well as to enhance their health conditions. An industrial work environment is composed of various factors like lighting, noise, temperature, and humidity that have a direct impact on the health condition of the workers. An amiable workplace escalates the manufacturing capacity, standard, and caliber of the workforce.

The present study aims to narrow the gap by investigating the health hazards and safety measures available in 22 garment industries from Tirupur, Tamil Nadu, India. Also, to examine the azo dye in wastewater released from garment industries. To the best of our knowledge, such a relationship was not been addressed in textile industries before especially in the Tirupur district of Tamil Nadu. Mainly the study examines the dye levels in wastewater and its implications on health aspects in textile industries. Hence the objective of the present study is to conduct a questionnaire survey on assessing the protective measures taken in the textile industries and the assessment of health among textile workers by measuring the levels of hazardous azo dye present in the wastewater and its effects on workers.

Materials and Methods

Study Population

Totally 832 study subjects were recruited for the present study, among them 84 were Managers, 136 Supervisors, and 612 Workers from various garment industries (n = 22) of Tirupur district, Tamil Nadu. The subjects were enrolled in the survey focusing on (i) assessing the health risks encountered by the participants and (ii) the list of safety measures ensured in the industries. The health risks were categorized as skin diseases, respiratory illnesses, cancers, and neurological diseases. The safety measures such as fire safety, emergency alarm, fire alarms, etc were included in the survey. The subjects were requested to participate in both surveys and the statistical analysis was performed after collecting the data. The participants were aware of the Occupational Safety and Health (OHS) protocol and its related risk factors while many workers were uneducated.

Study Design

The research design is the conceptual structure of the research procedure. It provides planning on the selection of subjects, methods for collecting relevant data, and data analysis techniques concerning the objectives of the research. A research tool mainly consisting of 13 major occupational health and fire safety parameters was designed in a questionnaire format. The questionnaire mainly focuses on the following guideline a) the current situation of the OHS system to provide service in any unexpected situation; b) difficulties in producing a prompt OHS service system, and c) current safety levels in their industries. The major icons of occupational health and fire safety included in the present study questionnaire were health and safety policy, fire safety equipment, smoke alarm installation, appropriate lighting, fire safety analysis and inspection, fire safety training, occupational health center, emergency preparedness, safety operating procedures, fire safety awareness programs, emergency light, fire alarms usage and inspection, fire drill practice and its frequency, alternate power, and roof access followed in garment industries. For easy access and a better understanding of the questionnaire, it was divided into two sections, where Section 1 contains general information about the garment industry and basic details about the study participants. While Section 2 gathers information related to the assessment of occupational health and fire safety elements. Levels are split into a rating scale consisting of three variables good, satisfactory, and poor.

The survey included the list of occupational diseases encountered generally in garment industries. The health risks include musculoskeletal diseases such as forearm tendinitis, Carpal tunnel syndrome, De Quervains tendinitis, osteoarthritis of the knees, epicondylitis, bicipital tendinitis, low-back syndrome, rotator cuff tears and tendinitis, trapezius spasm, sciatica, disc herniation, and cervical radiculopathy. Cancers such as bladder cancer, lung, and nasopharyngeal cancer, and hearing loss. Skin diseases such as contact and irritative dermatitis and lead poisoning. Also, our study mainly focused on exposure to azo dye from wastewater released from where the exposed chemical is hazardous in inducing nasal and lung cancer, brain cancer, and leukemia. These are the list of diseases included in the survey consisting of yes or no options.

Sampling Method

The questionnaire was mailed to the Human Resource Development Department, Personal Managers, and Chief Executives along with the guidelines and cover letter explaining the purpose of the study and requesting them to give necessary permission to carry out the collection of data in their industries for this study. Questionnaires were distributed to the respondents. Discussions were made with the Safety officers, Managers of the training and production departments.

Ozonation Process

The wastewater was treated with prepared azo dye, Reactive Orange 16, and ozonation was performed by two cleaning gas bottles containing 200 mL of an ozone measurement-related potassium iodide (KI) solution at a concentration of 2%. The MV-06 Multivácuo generator generated ozone using a 1.5 L/min oxygen flow. The ozone dose that was applied was set at 51.09 0.76 mg O_3/L. Ozonation tests were carried out for 2, 5, 10, 20, 30, 40, and 60 min to evaluate the experimental conditions enabling greater color removal efficiency and lower effluent toxicity. Different RO16 concentrations in solutions were used in the tests. The ozonation tests did not include any pH adjustments. The resultant ozonated RO16 solution was mixed with additional organic and inorganic ingredients to create synthetic wastewater, which was then submitted to biological treatment once the most suitable ozonation condition was determined. The method was followed as per the previous study stated by Castro et al. (2017) [7].

Wastewater Treatment

In the lab, a synthetic wastewater was created by combining the following substances with ozonated or non-ozonated dye solutions: using glucose as the primary carbon source to achieve a COD of 400 mg/L, K_2HPO_4 (4.45 mgP/L) and KH_2PO_4 (4.55 mgP/L) as phosphorus sources, NH_4Cl (30 mg NH_4^+-N/L) as a nitrogen source, $NaHCO_3$ (270 mg/L) as an alkalinity supply, and a trace element solution.

Biological Treatment

Two glass-made bioreactors were fed with wastewater treated with ozonated and non-ozonated azo dye solution. At the base of the reactors, a porous air diffuser connected to a compressed air line provided aeration. 6 hours were chosen for the hydraulic retention time (HRT). A municipal sewage treatment facility's activated sludge was used to inoculate both reactors. For the first two weeks, they were used in batch mode. No dye was present in the wastewater used to feed the reactors during this start-up period, which was designed to encourage the establishment of biofilm on the carrier media. Additionally, no analytical measurement was made during this preliminary phase. Following this time, the reactors were put into continuous operation to acclimate the biomass, but the influent medium was still being produced without the inclusion of the dye or the by-products of its ozonation-induced breakdown. Since then, the effectiveness of both bioreactors in terms of COD and ammonium removal has been evaluated. The 40-day biomass adaption period is in continuous mode. Then, to the influent of R1 and R2, respectively,

the azo dye solution (non-pre-treated) or the RO16 ozonation pre-treatment products were introduced.

Analytical Treatment

With an initial RO16 concentration of 25 mg/L, the dye absorption spectrum was also scanned before and after ozonation using a spectrophotometer.

Data Analysis

Data collection, organization, and analysis were done concurrently. All questionnaires were transcribed verbatim in Tamil to prepare transcripts and the text was translated by the researcher into English. Further, the survey data were imported into SPSS v 25.0. The safety measures and responsibilities of participants recorded via a questionnaire were statistically assayed. The $\chi 2$ test was performed to evaluate the association between the outcome and the variables, considering the entire period studied. The significant values were recorded if found to be less than 0.05.

Results and Discussion

In the present study, the demographic characteristics of the study participants such as their age, sex, education, salary, work shifts, textile sector, and service experience were elaborately explained in Table 1. From our study, we found that there was a predominance of male workers (418; 68.3%), supervisors (87; 63.9%), and managers (58; 69.0%) than to female workers (194; 31.6%), supervisors (49; 36.0%) and managers (26; 30.9%). As for schooling, most workers were uneducated (481; 78.5%) while most of the managers were educated (77; 91.6%). The majority of the workers had an average monthly income ranging from 10 K to 15 K or 15 K to 20 K whereas the managers had obtained a huge monthly income of more than 40 K. Further, regarding the time of employment, the highest incidence of typical occupational accidents occurred among workers between the years 5 to 8 years (48.3%). Concerning the textile sector, the rate was 36.6% higher in the production sector of the garments compared to the packaging (35.7%) and initial processing of the work (27.6%). Table 2 depicts the pilot line information about the garment factories from Tirupur district, Tamil Nadu, India. In our study, we found that five out of the twenty-two garment industries have only partially equipped fire safety equipment when compared to the others.

Data analysis is the process of arranging the raw data into meaningful information. In the present study, the relevant data obtained from the administered research tool have been analyzed. The factors included among the fire safety measures in our questionnaire included the health and safety policy, fire safety equipment, smoke alarm installation, fire safety committee, fire safety budget, fire extinguisher category, extinguisher workability, appropriate lighting, fire safety inspection, fire accident reporting, fire safety analysis and inspection, fire safety training, and periodic retraining followed in garment industries were collected from garment workers, supervisors and managers employed in 22 industries located in Tirupur and the collected data on occupational health and fire safety parameters from 22 garment industries from Tirupur district were explained clearly in Table 3. Thus, to assess the work environment all these parameters were studied in depth to arrive at a valid conclusion. The overall responses from each study participant (workers, supervisors, and managers) on the Health and Safety Policy of fire safety management elements in garment industries were categorized as Good (363), Satisfactory (673), and Poor (1564). Interestingly, the chi-square test also revealed that all the fire safety management-related responses showed statistically significant levels when compared among the good, satisfactory, and poor responses obtained from each study participant ($p<0.05$).

The responses (good, satisfactory, and poor) by each study participant separately for the fire safety measures have been clearly explained in Table 4. Our results showed that mostly the workers have provided a poor response against the safety measures in their industries when compared to the supervisors and the managers. Also, the Chi-square test revealed that the comparison of responses obtained from each different group of study participants was statistically significant ($p<0.05$). Table 5 depicts the health diseases such as musculoskeletal diseases, cancers, and skin diseases in garment industry workers, supervisors, and managers. The chi-square test revealed that the comparison of responses obtained from each different group of study participants was statistically significant ($p<0.05$). The effect of azo dye has been examined and found that within the first two hours of the anaerobic process, COD contents dramatically fell; however, at all concentrations of an azo dye, there was no discernible decrease in COD concentration during the remainder of the anaerobic process. Also, we examined how frequently the fire drill practice is conducted among managers, supervisors, and workers. The workers ($n = 47$) are the majority group performed with fire drill practice than managers ($n = 14$) and supervisors ($n = 39$). The inspection of fire alarms was also enquired about where we found $n = 3$ frequent inspection; $n = 2$ neutral; $n = 6$ infrequent inspection and $n = 1$ 1 disagreed with inspection.

India has been exporting ready-made garments to more than 100 countries comprising the USA and a few countries in Europe, Latin America, and the Middle East. The industry accounts for about 40 percent of the total textile exports [8, 9]. Wan (2012) portrayed on implementing the statutory components for the OHS management system model in the working environment of a textile testing laboratory in Hong Kong and recommended that the suitability of the recognized OHS

Table 1. General characteristics of the study participants.

Variables	Study Participants			p-value
	Workers (n = 612)	Supervisor (n = 136)	Manager (n = 84)	
Sex				
Male	418 (68.3%)	87 (63.9%)	58 (69.0%)	0.0001
Female	194 (31.6%)	49 (36.0%)	26 (30.9%)	
Age				
15 to 20 years	27 (4.41%)	0	0	0.0001
21 to 30 years	79 (12.9%)	26 (19.1%)	13 (15.4%)	
31 to 40 years	281 (45.9%)	15 (11.0%)	39 (46.4%)	
41 to 50 years	212 (34.6%)	83 (61.0%)	26 (30.9%)	
51 years & above	13 (2.12%)	12 (8.82%)	6 (7.14%)	
Education				
Educated	131 (21.4%)	81 (59.5%)	77 (91.6%)	0.0001
Uneducated	481 (78.5%)	55 (40.4%)	7 (8.33%)	
Salary				
10 to 15 K	379 (61.9%)	0	0	0.0001
15 to 20 K	121 (19.7%)	0	0	
20 to 25 K	89 (14.5%)	61 (44.8%)	0	
25 to 30 K	14 (2.28%)	39 (28.6%)	16 (19.0%)	
30 to 40 K	9 (1.47%)	21 (15.4%)	31 (36.9%)	
40 K & above	0	15 (11.0%)	37 (44.0%)	
Work Shifts				
8:30am to 9:00 pm	412 (67.3%)	91 (66.9%)	52 (61.9%)	0.0001
8:30am to 1:00am	101 (16.6%)	33 (24.2%)	23 (27.3%)	
8:30am to 5:00 am	99 (16.1%)	12 (8.82%)	9 (10.7%)	
Textile Sector				
Packaging	219 (35.7%)	66 (48.5%)	36 (42.8%)	0.0001
Production	224 (36.6%)	45 (33.0%)	29 (34.5%)	
Initial work	169 (27.6%)	25 (18.3%)	19 (22.6%)	
Service experience				
1-4 years	81 (13.2%)	28 (20.5%)	34 (40.4%)	0.0001
5-8 years	296 (48.3%)	56 (41.1%)	29 (34.5%)	
9-12 years	115 (18.7%)	33 (24.2%)	12 (14.2%)	
More than 12 years	120 (19.6%)	19 (13.9%)	9 (10.7%)	

p-value less than 0.05 significant

management system has to be measured and examined so that improvements could be recognized as well as also implemented in the industries [10]. The OHS services especially in a few villages in India are still in their initial stages. Therefore, the OHS mainly works only to fulfill the basic needs of the workers that to only for those who are working either in big industries or any other manufacturing industries. Hence, the major aim of the present study was to conduct an analytical research study to verify the possible implications related to the health aspects, fire safety precautions, and the roles and responsibilities handled by OHS management for the

Table 2. Pilot Line information about the Garment Factories.

Garment Factory	Product of this factory	Production pieces/ month	No. of Workers	Plot line information	Fire safety precautions
GF#1	T- shirts, Jacket, Female top wear	9,00,000	3000	27 Workstation; Gender: M = 60%; F = 40%, Mean worker age: 34 y.	Fully equipped with fire safety measures
GF#2	T- shirts, Polo T-Shirt, Baby wear	10,50,000	9000	33 Workstation; Gender: M = 70%; F = 30%, Mean worker age: 29 y.	Fully equipped with fire safety measures
GF#3	Female Leggings, pants and Baby wear	2,00,000	900	7 Workstation; Gender: M = 80%; F = 20%, Mean worker age: 41 y.	Partially equipped with fire safety measures
GF#4	Dress, Noos top, T-shirt, Polo shirt	9,00,000	2800	19 Workstation; Gender: M = 45%; F = 55%, Mean worker age: 35 y.	Fully equipped with fire safety measures
GF#5	T-shirt, Polo shirt, Sweatshirt, Tops	30,00,000	12000	39 Workstation; Gender: M = 55%; F = 45%, Mean worker age: 31 y.	Fully equipped with fire safety measures
GF#6	Female and girls kurtas and Leggings	10,50,000	8000	16 Workstation; Gender: M = 45%; F = 55%, Mean worker age: 41 y.	Fully equipped with fire safety measures
GF#7	Men's Inner Wear and Kids dress	4,60,000	2600	9 Workstation; Gender: M = 75%; F = 25%, Mean worker age: 38 y.	Fully equipped with fire safety measures
GF#8	Female Leggings, pants and Baby wear	3,00,000	1200	8 Workstation; Gender: M = 25%; F = 75%, Mean worker age: 29 y.	Partially equipped with fire safety measures
GF#9	Female and girls kurtas and Leggings	9,00,000	7000	10 Workstation; Gender: M = 25%; F = 75%, Mean worker age: 32 y.	Fully equipped with fire safety measures
GF#10	Men's Inner Wear and Kids dress	3,20,000	3000	7 Workstation; Gender: M = 75%; F = 25%, Mean worker age: 36 y.	Partially equipped with fire safety measures
GF#11	T-shirt, Polo shirt, Sweatshirt, Tops	10,50,000	9000	16 Workstation; Gender: M = 45%; F = 55%, Mean worker age: 41 y.	Fully equipped with fire safety measures
GF#12	Dress, Noos top, T-shirt, Polo shirt	6,00,000	2900	19 Workstation; Gender: M = 45%; F = 55%, Mean worker age: 35 y.	Fully equipped with fire safety measures
GF#13	Female Leggings, pants and Baby wear	2,50,000	900	10 Workstation; Gender: M = 25%; F = 75%, Mean worker age: 22 y.	Partially equipped with fire safety measures
GF#14	Dress, Noos top, T-shirt, Polo shirt	1,80,000	2000	3 Workstation; Gender: M = 65%; F = 35%, Mean worker age: 25 y.	Partially equipped with fire safety measures
GF#15	Female and girls kurtas and Leggings	9,00,000	8000	7 Workstation; Gender: M = 75%; F = 25%, Mean worker age: 21 y.	Fully equipped with fire safety measures
GF#16	Dress, Noos top, T-shirt, Polo shirt	5,90,000	2600	4 Workstation; Gender: M = 65%; F = 35%, Mean worker age: 25 y.	Fully equipped with fire safety measures
GF#17	Female Leggings, pants and Baby wear	12,50,000	4200	13 Workstation; Gender: M = 35%; F = 65%, Mean worker age: 35 y.	Fully equipped with fire safety measures
GF#18	Female and girls kurtas and Leggings	5,00,000	950	4 Workstation; Gender: M = 45%; F = 55%, Mean worker age: 25 y.	Fully equipped with fire safety measures

Table 2. Continued.

GF#19	Men's Inner Wear and Kids dress	30,50,000	23000	23 Workstation; Gender: M = 65%; F = 35%, Mean worker age: 33 y.	Fully equipped with fire safety measures
GF#20	T-shirt, Polo shirt, Sweatshirt, Tops	8,00,000	5500	6 Workstation; Gender: M = 65%; F = 35%, Mean worker age: 35 y.	Fully equipped with fire safety measures
GF#21	Dress, Noos top, T-shirt, Polo shirt	9,00,000	7050	9 Workstation; Gender: M = 65%; F = 35%, Mean worker age: 42 y.	Fully equipped with fire safety measures
GF#22	Female Leggings, pants and Baby wear	10,50,000	9500	11 Workstation; Gender: M = 55%; F = 45%, Mean worker age: 34 y.	Fully equipped with fire safety measures

Table 3. Overall Responses on Fire Safety Elements in Garment Industries by all study participants.

Parameters	Responses			X^2	P-Value
	Good (%)	Satisfactory (%)	Poor (%)		
Health and Safety Policy	40 (4.80%)	110 (13.2%)	50 (6.00%)	825.5	<0.0001
Fire Safety Equipment's	35 (4.20%)	52 (6.25%)	113 (13.5%)	818.8	<0.0003
Smoke Alarm Installation	32 (3.84%)	32 (3.84%)	136 (16.3%)	537.1	<0.0004
Fire Safety Committee	29 (3.48%)	46 (5.52%)	125 (15.0%)	574.0	<0.0004
Fire Safety Budget	24 (2.88%)	62 (7.45%)	114 (13.7%)	610.9	<0.0004
Fire Extinguisher Category	14 (1.68%)	30 (3.60%)	156 (18.7%)	470.0	<0.0001
Extinguisher Workability	18 (2.16%)	34 (4.08%)	148 (17.7%)	496.8	<0.0002
Appropriate Lighting	18 (2.16%)	49 (5.88%)	133 (15.9%)	547.1	<0.0002
Fire Safety Inspection	34 (4.08%)	41 (4.92%)	125 (15.0%)	574.0	<0.0004
Fire Accident Reporting	11 (1.32%)	16 (1.92%)	173 (20.7%)	413.0	<0.0003
Fire Safety Analysis and Inspection	8 (0.96%)	52 (6.25%)	140 (16.8%)	523.7	<0.0003
Fire Safety Training	53 (6.37%)	107 (12.8%)	40 (4.80%)	859.0	<0.0006
Periodic Training/Retraining	47 (5.64%)	42 (5.04%)	111 (13.3%)	620.0	<0.0002

workers in various garment industries from Tirupur district, Tamil Nadu, India.

Garment workers are often affected by various categories of diseases mainly due to unhygienic workplace constraints and the dust produced from raw materials [11, 12]. Even reports suggest that they are also affected with various other health issues including coughs, fever, jaundice, kidney failure, musculoskeletal problems, respiratory issues, and many more and this has a huge impact on the production of the textiles [13]. Furthermore, as a majority of garment workers do not get complete payment when they are on sick leave, it gives them more concerns and they lack the care of their health condition. Also, the garment sector employee must have the right to work in an environment that is safe and without any risk to their health [14]. Therefore, the garment industry owners should note that if they need to increase their production with better quality then they should also provide a good environment as well as basic knowledge regarding the OHS and its procedures

Table 4. Safety Measures responses by different study participants.

Parameters	Workers (n = 612)			Supervisor (n = 136)			Manager (n = 84)			X^2	P-value
	Good	Satisfactory	Poor	Good	Satisfactory	Poor	Good	Satisfactory	Poor		
Health and Safety Policy	11	79	27	14	19	14	15	12	9	872.5	<0.0008
Fire Safety Equipment's	9	29	81	12	11	19	14	12	13	862.4	<0.0001
Smoke Alarm Installation	8	13	97	11	8	21	13	11	18	852.3	<0.0001
Fire Safety Committee	4	11	89	11	19	23	14	16	13	849.0	<0.0001
Fire Safety Budget	7	31	77	7	16	29	10	15	8	882.5	<0.0005
Fire Extinguisher Category	3	13	93	4	9	41	7	8	22	869.1	<0.0004
Extinguisher Workability	6	14	101	7	11	39	5	9	8	919.4	<0.0005
Appropriate Lighting	5	9	113	7	20	10	6	20	10	872.5	<0.0008
Fire Safety Inspection	4	11	101	15	15	19	15	15	5	874.2	<0.0003
Fire Accident Reporting	2	6	123	4	5	25	5	5	25	875.8	<0.0001
Fire Safety Analysis and Inspection	1	23	120	3	13	10	4	16	10	892.6	<0.0003
Fire Safety Training	22	79	29	14	16	6	17	12	5	879.2	<0.0002
Periodic Training/ Retraining	19	16	78	12	11	23	16	15	10	855.7	<0.0003

Table 5. Safety Measures responses by different study participants.

Health Parameters	Responses			X^2	P-Value
	Managers (n = 84) (%)	Supervisors (n = 136) (%)	Workers (n = 612) (%)		
Musculoskeletal diseases					
i) Forearm tendinitis	2 (2.38%)	11 (8.08%)	48 (7.84%)	2.45	<0.0001
ii) Epicondylitis	2 (2.38%)	-	8 (1.30%)	1.39	<0.0001
iii) Low-back syndrome	31 (36.9%)	49 (36.0%)	101 (16.5%)	4.89	<0.0004
iv) Osteoarthritis	8 (9.52%)	55 (40.4%)	110 (17.9%)	5.33	<0.0002
Cancer					
i) Bladder Cancer	4 (4.76%)	-	22 (3.59%)	3.89	<0.0001
ii) Lung cancer	3 (3.57%)	-	17 (2.77%)	3.10	<0.0001
iii) Nasopharyngeal cancer	3 (3.57%)	3 (2.20%)	85 (13.8%)	4.10	<0.0001
Skin diseases					
i) Dermatitis	13 (15.4%)	4 (2.94%)	50 (8.16%)	2.57	<0.0002
ii) Chemical poisoning	18 (21.4%)	14 (10.2%)	171 (27.9%)	3.98	<0.0002

to the workers for their safety purpose. In garment industries, the making of clothes includes performing boring, incredibly repetitive, and fast-paced tasks that frequently call for uncomfortable joint positions. The exposures put garment workers at risk of developing WRMDs (work-related musculoskeletal disorders) of the neck, upper extremities, back, and lower extremities. It is common for garment workers to develop several WRMDs, frequently in conjunction with concurrent soft-tissue conditions including tendinitis and nerve

entrapment syndromes like carpal tunnel syndrome. The development of musculoskeletal problems of the neck, shoulder, elbow, forearm/wrist, and low back is also a risk for cutters whose employment involves lifting and carrying fabric rolls as well as operating hand-held or computer-operated cutting machines.

The COD contents dramatically dropped during the first two hours of the anaerobic process. However, for all azo dye doses, there was no further discernible decline in COD concentration. These findings showed that ozonation enhanced the dye's capacity to degrade, producing less complex molecules that are simpler to digest aerobically. Souza et al. (2010) also found that azo dye biodegradability was improved. The effectiveness of R1 in terms of COD removal suggested that the activity of heterotrophic bacteria was unaffected by any of the intermediates derived from the oxidation pre-treatment, despite the low EC50 values and consequently relatively high toxicity of the RO16 solution after 5 min of ozonation [15].

In a previous study, the authors reported that the reasons for fire accidents in Tirupur garment industries comprise electric short circuits, faulty electrical wiring, smoking materials, boiler explosion, kitchen stove, and carelessness [16]. Hiremath et al, (2014) discussed the health safety and hazardous impact of the garment industries and reported that their safety mainly relies on the industry environment and the availability of medical facilities and centers [17]. Similar to these previous studies even in our present study, we conducted a questionnaire survey from various stages of employees (workers, supervisors, and managers) from garment industries of Tirupur regarding the fire safety in their workplace, but we found that most of the workers have provided poor responses regarding the safety measures and the OHS management systems available in their industries. Weh-hui-Ju (2016) brief the fire safety features referring to a hundred cotton logistics warehouse fires, relying on the relevant provisions of the cotton logistics warehouse. These studies show that even though in recent years, there have been noteworthy efforts to enhance the structural elements of fire safety, there still is a huge scope and gap to develop a proper system and protocols for fire safety in the garment industries [18].

In this study, we investigated fire alarm usage and its inspection in 22 industries. The practice of fire drill is mostly taken by the workers regularly so that they can face challenging situation when arises. The supervisors enrolled in practice were 39 which shows their involvement and its importance towards the safety of the industry. The managers were generally placed in offices hence their participation in fire drills is less when compared to other participants. In fire safety measures, the frequency of imparting fire drill practice was assessed in three categories in which industries imparting only once a year reported to be 35 which shows their lack of involvement in fire safety measures in their industries. This shows the infrequency of fire drills among 22 industries proves their improper guidelines communicated among people working in the industries. From the findings of our study, a similar pattern of observance was estimated by Habib et al. (2022) who conducted the study in Bangladesh population where the practice of fire drills was reported to be agreeable among workers and the practice was conducted mostly half-yearly in industries. Likewise, we examined the usage of fire alarms and their inspection which was reported to be improper usage and disagreement Whereas a study carried out in Bangladesh reported proper fire alarm usage and inspection [19].

Conclusion

Through this study, we observed a huge gap between the needs and available reserves in certifying the OHS services in India. Also, it was observed that unsafe working condition could decrease productivity and reduce the interest of workers. The importance of the study can be reviewed by considering its social as well as scientific significance as these epidemiological data obtained from questionnaires could help to plan proper safety measures for the workers, their health status monitoring, and regularizing the inspection of safety measures by OHS management. This study will enhance the productivity rate by eliminating the hazardous environment among workers. Thus, the study shows precautionary measures are not taken and necessary steps are missing in implementing fire safety practices. Also, from the wastewater assessment, the outcomes demonstrated how effectively RO16 azo dye was degraded by ozone oxidation. In both systems, the average ammonium and COD removal rate was higher than 90%. In conclusion, the government should take a stand on this issue as it will be essential for regulatory departments to see the potentially hazardous industries to secure the health of workers. Hence, more research is needed to confirm these results and to learn about the possible health effects on workers and how to safeguard them with the best possible fire safety measures.

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Conflict of Interest

The authors declare no competing interest.

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