Study of Physical, Chemical and Ergonomic Occupational Hazards Faced by Photocopy Machine Operators

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Abstract: Photocopy machines are a source of indoor air pollution. This study, conducted at Gulberg, Walton, D.H.A, Shadman, R.A.Bazar, Barket Market, Firdous Market, and Nabah road in Lahore aimed at assessing the occupational hazards to which photocopy machine operators are exposed. The study was conducted in hot and cold season for monitoring at 36 sites among 126 photocopy operators by socioeconomic survey. Very few operators (12%) used protective measures. 47% of the operators had visual discomfort from machine's light while only 27% got disturbed from the noise of the machine. Noise level at majority of the photocopy shops were within the Standard limits (70dBA). PM_{10} concentration at majority of the shops exceeded the 250 $\mu g/m^3$ ambient air quality standard. Statistical analysis of the Air pollutants (VOC, PM_{10}, O_3, CO, SO_X) showed a high statistical significance as the p value was < 0.005. Dry mouth was most common health issue among the photocopy operators and was most frequent in age group 35 to 40 while fatigue and headache were the most common health outcomes affecting all age groups almost in the same frequency. Ergonomic issue comparison showed that neck pain and swelling of feet was most frequent in age group 35 – 40 and 41 – 46. Back pain was most common ergonomic problem affecting all the age groups. A strong positive correlation exists between PM_{10}, Ozone, Carbon monoxide, SO_x emitted from the photocopy machine. Emission levels of PM_{10}, VOC, Ozone, CO, SO_x were significantly high for Winter when compared with that of Summer season.

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1. Introdution

Workplaces of workers hadnot always have been safe, poor lightening, noise, heat stress, ventilation, extra working hours, low wages were common challenges, which did improve to some extent in the course of the nineteenth century **[1].** Ill health effects of industrial workers brought into focus the health and safety risks at work place which gave rise to the discipline of Occupational health and safety which covers occupational hazards and injuries. Bernardo Ramazinni, an Italian physician recognized more than 200 years ago that work may adversely affect workers health and productivity **[2].**

Photocopying process depends on the principle of electrophotography **[3]**. Rochester in 1906 founded Xerox. In 1958 its name was changed from Haloid Photographic Company to Haloid Xerox and got fame due to Xerox 914, the first-ever commercial push button photocopier using the process of Xerography, developed by Chester Carlson **[4,5]**.

Little information is available on occupational injuries and perceptions of hazards in informal sector. Most of the photocopy machines are placed indoor, the area being commercial and workers being bound to work in small, confined shops resulting in indoor air pollution. However attention is now being given to the potentially dangerous emissions from photocopy machines **[6].**

Different approaches to legislation, regulations and enforcement of occupational health and safety are present in different developed countries. Still OH&S related research has been limited in the developing countries. Eventhough these nations contribute considerably to the world population and the incidences of health issues are greater, only around 10% of health and safety research has taken place **[7,8].**

Pakistan, like many other developing countries has been undergoing a transitional phase in its economy. Globalization of the world trade has brought around new challenges in the field of OH&S **[8].** In the early days the country lacked the basic infrastructure and qualified personnel for providing occupational health and safety services to the workforce **[9].**

In Pakistan the occurrence of occupational illness and injuries has been in large number in the recent years as the workers get exposed to dangerous chemicals and many routinely work in hazardous industries. Many of the accidents go unreported as the regulatory agencies lacked effective enforcement policy and strict reporting requirements, thus a lack

of reliable data regarding OHS illness and injuries **[10].**

Factories Act,1934 required only general level of health and safety measures and is practically outdated. Certain essential sectors like agriculture, informal / self-employed were not even covered under any law **[11].**Labour Policy initiative was announced in 2001 along with the proposal for a council for reviewing, updating and setting targets for the overall improvement of health sector **[8,11].**Labour Policy 2002, Labour Protection Policy 2005, and the associated legislation provided a framework for worker protection but labour related matters were beyond the competence of the relevant institutions **[12]**.Labour policy 2010, aimed to benefit the informal economy workers from improved safety and health arrangements, access to social security arrangements, and the payment of minimum wages. **[13]**

Majority of workforce is illiterate and lacks awareness and training in occupational health and safety, thus exposing a large number to risk if further attempts to improve OH&S are not made **[8,11].**With the passage of time the changing working life required increasing adaptation of occupational health, hygiene and safety requirements at different workplaces **[14].** In the last decade, little information on OH&S was available in Punjab Province **[8].**

Indicators of occupational health and safety tend to provide early signals for problems at Workplace and are collected in some form in nearly every country **[15]**. Different types of physiochemical exposures include physical, mechanical, chemical, biological agents and ergonomics hazards which workers may face at workplace **[15]**.Toner, selenium, ozone, VOCs, electromagnetic radiation, photocopier lights,, heat and ergonomics are some of the concerns at photocopy shops **[16, 17, 18, 19, 20]**

As the workers have been occasionally exposed to hazards at work place, finding permissible limits of exposure to emissions and other hazards had been an objective for many nations. Thus National Standards have been developed and adopted to limit the hazards exposure and as a instrument to compare the workers exposure limits with.On 10th May, 1993, Pakistan Environment Protection Council in its first meeting approved the NEQS which included 32 parameters prescribing permissible levels of pollutants in liquid effluent while 16 parameters for gaseous emission. Then in December 28, 1999, PEPC approved the revised NEQS. Later NEQS for Ambient air and Noise were also established by Pak – EPA.

The revised version of Ambient Air Quality standards and Noise were notified in 2010. These are the maximum limits of certain air pollutants in the environment to which individual can be exposed to without getting health related problems. For noise, the area to be monitored has been categorized into 4 zones, with different limits for day time and night time.

Occupational Safety and Health Administration, (USA agency) issues health and safety regulations under Occupational Safety and Health Act in order to assure a safe and healthy working environment to the workers. Permissible exposure limits (PELs), based on an 8-hour time weighted average (TWA) exposure are regulatory limits on the amount or concentration of a substance in the air to which workers can be exposed to without having any ill health effects.

Over the years photocopy has become a mandatory component of offices, schools, bookstores as it has brought ease to our busy schedule Work plays an integral part in a person's live. Up to 80% time is spent indoors of which 30% time at workplace. Many things exist in the workplace that adds to discomfort, stress and even injury. In a developing country like Pakistan, less consideration has been given to health and safety of workers, work place design and control measures are inadequately incorporated.

Furthermore due to high illiteracy rate and lack of awareness the workers are exposed to occupational hazards either directly or indirectly which in most cases are not even perceived as hazards. The occupational illness and injury as a result greatly affects the worker's work capacity and puts psychological strain.

Photocopying presents potential hazards including ozone emission, toner dust, light, heat, noise, as well as discomfort and strain to the workers using them for long period of time. It is now become the need of the development era to incorporate and implement OHS aspect to help recognize a number of occupational hazards and some type of work generally associated with those hazards which initially are being overlooked, to provide a safe work environment. It is also necessary that the workers recognize these hazards as well.

The present study was planned to assess the occupational hazards to which photocopy machine operators were exposed to and to correlate emissions emitted and compare the emission levels on seasonal variation basis. The study was under taken as photocopy has become a common practice, more and more photocopy machine operators are routinely exposed to the associated hazards and mostly being unaware of them.

The present study is undertaken to:

- Determine the general level of awareness of the photocopy operator about health and safety issue.

- Monitor the prevailing air pollution level (SO_x, CO, O_3, VOC, PM_{10}) and noise at the operators workplace.
- Conduct ergonomic evaluation of posture and MSDs of the photocopy operators through questionnaire based interviews.
- Assess the correlation between the emissions emitted at photocopy centers within the study area.

2. Material And Methods

The study was conducted at Gulberg, Walton, D.H.A, Shadman, R.A. Bazar, Firdous market, Barket market and Nabah Road in Lahore. Field survey of 86 photocopy shops were done for data collection while air quality assessment was done at 36 photocopy shops. Convenience sampling technique was used. Socio economic survey using semi structured questionnaire of 126 photocopy operators was done, sample size calculated using sample size calculator.

BMI of 77 Photocopy machine operators, aged 17 – 62 years was calculated. Noise level meter (Leader test Instrument – model OS 11) was used for the measurement of noise level (Leq value) at different sites with in the study area. PM sampler (The Casella) was used for ambient air and dust monitoring. Minimum detection limit was upto 10μg/m^3 size of PM in ambient air. 8 hour average monitoring of particulate matter was done. The photocopy machine operators' work shift was divided into three parts for monitoring and the average of the three readings was taken out.

The equipment used for VOC, O_3, SOx, CO monitoring was Midget impinges.5ml of chemical solution was poured in glass impinges and assembled with the suction machine. Air of the work place was then sucked into impinges where it passed through the solution contained in it, volume of which indicated of the calibrated volume measuring gauze.

After monitoring the used solutions were poured in air tight containers and sent to laboratory for analysis for which standard laboratory procedures were followed. Standard Methodology number: 43501-01-71T was used for VOC analysis and Methodology number: 44101-03-71T for Ozone. Pararosaniline method for SO_x analysis while Mini Warn Multi Gas Inivonitor method for CO analysis was used.

As no equipment is present by which ergonomics can be measured so it was assessed by observation and posture related ill effects among the workers while carrying out the field survey and interviewing the workers.

Two software were used, SPSS for windows and Excel version 2007 for analysis of data and graph plotting respectively.Frequencies of the different variables were found along with the Person Correlation, Regression and Sigma 2 tailed test using SPSS software.

3. Results And Discussion

Photocopy Operators were categorized into 8 Age groups. Data tabulated in Table 1 revealed that out of 126 photocopy machine operators, majority (26%) were of age group 23 -28 years while 4% were of age group 47 to 58 years. BMI calculation of 77 photocopy machine operators showed that majority of the operators fall under normal range while 29% were overweight and 19% were underweight (Table 2). Long work shifts and lack of interactive activities results in greater number of improper BMI which increases the chance of presence of disease among the operators **[21].**

Table 1: Age group of the operators

Age Group (years)	No. of Photocopy machine Operators
17 - 22	29
23 - 28	33
29 - 34	30
35 - 40	18
41- 46	7
47 - 52	4
53 - 58	4
59 - 64	1

The education profile of 126 photocopy machine operators showed that 2% were illiterate, 6% primary, 25% middle, 45% matric, 18% inter while 4% were graduates. Majority of the operators had done matric as most of the shops had a set criteria of employing matric pass as operators. General awareness about health and safety issues was less as only 15 photocopy machine operators slight responded to them (Table3). 25% had awareness that job/ work could have a health concern while 58% were aware of different issues related to photocopy machines. Light though not having serious health effects was considered most frequent health hazard as it is the most obvious item which can be observed. Only 33% had awareness regarding the working postures and its impacts.The lack of awareness of these postures results in pain in different body parts and reduction in productivity. Majority (65%) of the photocopy machine operators didn't knew about the Protective measures. This low awareness level results in exposure of these operators to potentially dangerous chemicals and situations, manual refilling of cartridges and cleaning toner powder with bare hands thus maximizing skin contact, lack of proper

hand washing before consuming edibles promotes intake of toner chemicals. Akram reported lack of awareness and highlighted the need of training in occupational health and safety to prevent the exposure of workers to hazards **[11].**

Table 2: Body mass index of operators

BMI	Frequency
Underweight	15
Normal	34
Overweight	22
Obese	6

Table 3:Awareness of operators

Response	Health and safety	Occupational health and safety	Photocopy hazard	Working postures	Protective measures	Ventilation	design/ area of work place
Yes	15	32	74	42	35	90	60
No	111	94	52	84	65	36	66

Majority (71%) operators considered ventilation of work place to be important. Majority (53%) operators had no concern about the design/ area of work place. As operators spend a lot of time in there work place, they should be appropriate along with the proper working height.

Data Analysis of working years of 126 workers revealed that majority (30%) of them had been working on photocopy machines from 4 to 6 years, while 2% have been on this job from 19 to 21 years (Table 4).Majority of the operators (53%) worked for 11 – 12 hours while the 8 hour work duration was not seen in any case (Table 5). Extensive working hours and long working years may be a contributor of fatigue and head ache seen among the photocopy machine operators as supported by the work done by Sarder **[22].**

Table 4: Working years of operators

Working Years	Frequency
1 -3	33
4 – 6	37
7 – 9	23
10 - 12	14
13 – 15	5
16 - 18	11
19 - 21	3
Total	126

Table 5: Working hours of operators

Daily Working Hours	Frequency
7 – 8	0
9-10	41
11-12	67

In photocopying process, light laser passes across the glass screen as the image is copied on the paper, the intensity of which is enough to cause visual discomfort. Data analysis revealed that almost half of the photocopy workers had vision disturbance (Table 6). 18 operators had it before joining this work while in majority vision problems occurred after working on photocopy machines.

Table 6: Frequency of Smokers and Vision disturbance

Responses	Smoking	Visual disturbance
Yes	65	60
No	61	66
Total	126	126

51% operators were smokers while 49% were non smokers. Out of the 65 smokers, 57 were regular smokers while 9 respondents seldom smoked at work. Smoking could be a factor contributing to dry mouth, sore throat and respiratory track problems among the operators. Further more the carboxy hemoglobin range of blood in cigarette smokers is 4 to 20% thus reducing blood's oxygen carrying capacity **[23].**

Work place specification details observed and collected are tabulated in Table 7. Majority (94%) of the shops had air circulation system (fans). Air circulation is vital for air movement. As the study coved seasonal variation aspect, majority of fans were non operational due to cold season, however during the summer season 75% were operational. 72% of the shops had ventilation systems, majority having 1 exhaust/ shop, while 28% didn't have exhausts. Out of the 62 exhausts overall 65% were operational. Ventilation is needed to remove excess heat, dust particles and moisture produced as well as harmful gases, emissions and disease causing organisms that may be present.

As photocopy machines produce heat and due to congested work places, Majority (64%) of the work areas were warmer. Only 38% of the shops had Air Cooling facility, out of which 64% were non operational at the time of monitoringas AC consumption greatly increases electricity bill.

Toner cartridge of photocopy machine needs to be filled after being consumed up before making further photocopies. 58% operators filled the toner

powder themselves as it was convenient and cheaper for them (Table 8). While refilling the toner the operators come into direct contact with it and also resulting in its becoming airborne, exposure to which leads to pulmonary disease **[24, 25].**Data revealed that most of the maintenance (68%) of the photocopy machine was done by the operators themselves despite having low awareness of occupational hazards. Out of these 88% didn't use any sort of protection while doing maintenance of the machine**.**Cloth was frequently used as the protective measure.Majority (76%) of the operators didn't turnoff the machine before opening it to remove paper jams exposing them self to potential electroshocks**.**

Table 7: Work place Specifications of the 86 sites collected within the study area

Specifications	Response	Frequency
Circulation system	No	4
	Yes	82
Ventilation system	No	24
	Yes	62
Cooling facility	No	53
	Yes	33
Warmer in work place	No	31
	Yes	55
Work place congested	No	33
	Yes	53
Adequate Light	No	37
	Yes	49

All sorts of factors can help define the work place environment, but the location and nature of seating arrangements in the workplace can have a significant impact on the productivity, body postures and satisfaction of workers. Data collected regarding sitting arrangement, working height, inclined posture, Injury at work, workplace temperature is tabulated in Table 9. Buildings which have no artificial cooling systems have hot conditions in summer season and it is likely that some people will start to experience some degree of discomfort, the common symptoms being complaints of tiredness, lack of concentration and headaches. But the incidence of thermal discomfort in these circumstances can be reduced by opening windows and the use of fans to increase air movement. Out of the 126 operators questioned, 67% considered the working temperature not comfortable and 44% of them have had heat stress while at work. 52% of operators maintained appropriate posture while operating the machine. 48% didn't smell any odor in the work environment which could have been removed through ventilation or the workers had got normalized with that peculiar smell. Though drinking water was available to 65% of the workers, but the drinking water facility was not proper. Working with the body in a neutral position and posture reduces stress and strain on the muscles, tendons, and skeletal system and reduces the risk of developing a musculoskeletal disorder (MSD).

Table 8: Work related activities performed by operators at work place

Associated activities	Responses	Frequency
Refilling of toner	Manufacturer	53
	Self	73
Maintenance done by	Self	86
	Technician	40
Machine Turned off before checking jams	Yes	30
	No	96
Protective measures used	Yes	15
	No	111

Table 9: Physical aspects of work place faced by operators

	Responses	Frequency
Sitting arrangement	No	21
	Yes	105
Appropriate working height	No	27
	Yes	99
Inclined posture	No	65
	Yes	61
Injury at work	Frequent	48
	Seldom	78
Overall comfortable Working temperature	no	84
	yes	42
Smell irritating odor	no	66
	yes	65

Observations made during survey revealed that majority (65%) of the photocopy machine operators didn't close the machine lid before photocopying.

Photocopy light may cause eye irritations when the lid is not closed during photocopying. 47% of the operators had eye irritation when exposed to photocopy machine light/ laser, while the rest had become used to it. 73% of the operators didn't get affected from the noise of the photocopy machine, while 27% got disturbed from the noise. When questioned for hearing disturbance, 20% had hearing problem. Long exposures to noise and proximity to noise source increases the chance of hearing damage (Table 10).

Different shops were monitored within the study area to assess the Occupational hazards faced by the photocopy machine operators in Lahore. Results of the parameters (Noise, PM_{10},VOC, CO, SO_x, O_3) monitored at 36 sites in different localities within the study area (Lahore) are tabulated in Table 11.

The descriptive stats showed that overall operators were exposed to minimum noise level of 59.7 and maximum of 76.3 dBA, which exceeds the standard limit value of 70dBA (Table 12). Exposure to noise has been reported by Vermeer to induce hearing disorder, hypertension, irritation, ischemic heart disease, sleep disturbance and decreased performance **[26].** Comparison of noise level at 36 sites with Commercial noise standards NEQS showed that majority of the shops were in compliance with the standards. Only a few shops slightly exceeded the standard values of 70 dBA. In certain shops noise was not due to the photocopy machines instead was due to secondary factors, large open fronts, proximity to road.

Particulate Matter (PM) measured at 36 shops within the study area was compared with the ambient air quality standards of NEQS, Pakistan, having a limit value 250 µg/m^3. Only few shops were in compliance while majority of the shops had PM level greater than the standard limits, thus making PM a key pollutant in the work place of the Photocopy operators which the descriptive stats showed that overall operators were exposed to minimum noise level of 59.7 and maximum of 76.3 dBA, which exceeds the standard limit value of 70dBA (Table 12). Exposure to noise has been reported by Vermeer to induce hearing disorder, hypertension, irritation, ischemic heart disease, sleep disturbance and decreased performance **[26].** Comparison of noise level at 36 sites with Commercial noise standards NEQS showed that majority of the shops were in compliance with the standards. Only a few shops slightly exceeded the standard values of 70 dBA. In certain shops noise was not due to the photocopy machines instead was due to secondary factors, large open fronts, proximity to road.

Table 10: Visual and hearing discomfort in operators

	Responses	Frequency
Close machine lid before photocopying	no	82
	yes	44
Eye irritation from machine Light	no	67
	yes	59
Disturbance from sound of Machine	no	92
	yes	34
Hearing loss	no	101
	yes	25

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When questioned regarding the health related issues, findings revealed that 94 operators had dry mouth, 53 had got itching, 52 had blurred vision, 55 had abdominal cramps, 62 had respiratory track problem, 70 had sore throat, 67 had dry eyes while 17 had skin rash (Figure 1). Analysis revealed that 105 operators felt fatigue, 48 felt restlessness, 58 felt weakness, 101 suffered head ache, 68 sensed/experienced dizziness, 59 frequently had mood swings, 48 dehydrated, while 22 had fainted at work (Figure 2). As the Work places are mostly confined, the exposure levels to the workplace hazards are higher than in general environment. Psychological stress and mood swings may be associated with sleep disturbances and over time/ part time job routine of the workers. Occupational symptoms like eye, nose, throat irritation, headache and fatigue, dizziness have been associated with emissions from photocopy machine **[28].**

Table 11: Result of parameters sampled at different shops within the study area

Area		Physical Hazard	Chemical Hazards				
		Noise L.eq (dBA)	PM_{10} ($\mu g/m^3$)	VOC ($\mu g/m^3$)	OZONE ($\mu g/m^3$)	CO ($\mu g/m^3$)	SO_x ($\mu g/m^3$)
GULBERG							
1	Prime graphics	68.4	283	2.1	0.9	56	40
2	Pak photocopy	71.6	272	1.7	0.3	70	44
3	Haroon Photocopy	70.8	277	1.8	0.7	65	42
4	Omer graphics	70.4	300	2.6	1.1	61	40
5	Mujahid Photocopy	71.2	289	2.4	0.9	60	40
6	Azeem photocopy	70.1	278	1.9	0.6	66	42
BARKAT MARKET							
7	Lala Photocopy	62.6	188	1.1	0.9	68	42
8	Tariq photocopy	70.2	253	1.4	.4	67	44
9	Abid Photocopy	65.4	199	1.3	0.7	61	40
10	Omer Photocopy	67.9	223	1.1	0.6	56	39
11	Sun rise photocopier	72.4	295	2.5	1.2	64	42
SHADMAN							
12	Kazim photocopy	69.4	289	2.2	0.9	58	42
13	Book way photocopy	71.8	269	1.5	0.4	69	46
14	Dawood photocopy	72.1	298	2.4	0.9	60	43
15	Ishaq photocopy	69.1	265	1.5	0.8	60	42
16	Al Rehman photocopy	68.1	275	1.9	0.7	58	42
17	Noman Photocopy	72.3	290	2.1	0.8	61	44
R.A. Bazar							
18	Ajmal Book shop	71.2	310	2.01	4.9	77	53
19	Iqra Photocopy	69.9	303	1.04	3.9	80	50
20	Jamshaid photocopy	72.6	344	2.2	4.2	84	52
21	Mughal Photocopy	74.1	413	2.7	1.9	78	50
22	Maqbool photocopy	72.8	357	1.2	4.3	88	55
FIRDOUS MARKET							
23	Zouk Photocopy	70.2	255	3.2	0.89	79	52
24	Amjad photocopy	68.1	376	1.7	0.9	72	47
25	Chaudary Photocopy	76.3	419	5.3	2.9	90	59
26	Rehman Photocopy	63.4	283	1.9	0.81	68	50
27	Shaukat photocopy	73.7	440	2.1	3.2	80	55
NABAH ROAD							
28	Alla Photocopy	72.6	392	4.1	1.04	88	55
29	Ravi Photocopy	69.7	305	4.9	0.98	80	51
30	Hussain photocopy	70.9	311	5.9	2.01	79	52
31	Waseem photocopy	74.4	406	1.7	2.71	76	50
D.H.A							
32	Mabrook Photocopy	72.5	373	4.2	2.2	86	57
33	English Book shop	73.8	343	3.7	1.3	80	53
34	Barkat Ali Photocopy	71.8	417	5.5	2.9	90	60
35	Universal photocopy	70.9	274	1.1	0.7	61	44
Punjab University							
36	STC	59.7	183	0.8	0.81	44	40

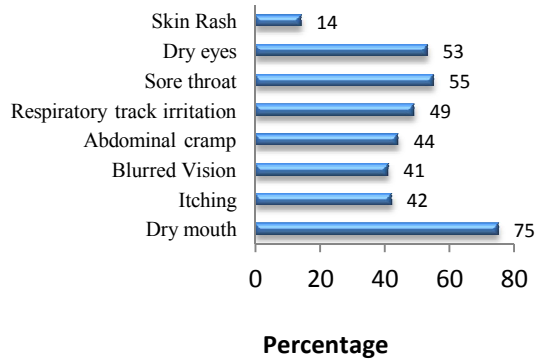

Figure 1: Health related issues in photocopy operators

Different work related posture problems were observed among the workers (Figure 3). Proper health and safety aspect at the work place is difficult to maintain when financial resources and OHS trained personals are not available. In these cases work related issues become a major problem as the workers lack general awareness.

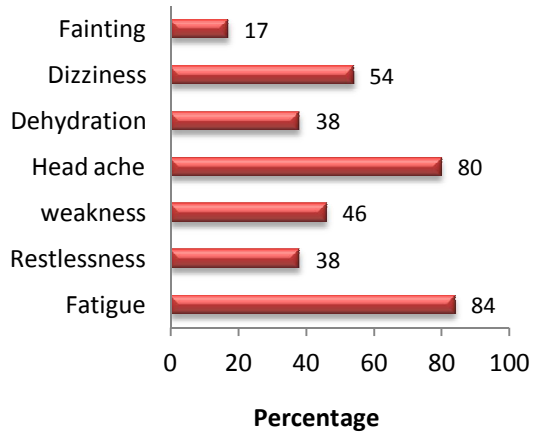

Figure 2: Health related issues among photocopy workers

Working years of employees affects the stamina, their working practice, their adaptation to the environment and the normalization of certain aspects of environments and hazards. Data of percentage of Health effects on operators with respect to their duration of working years on photocopy copy machine is tabulated in Table 13.

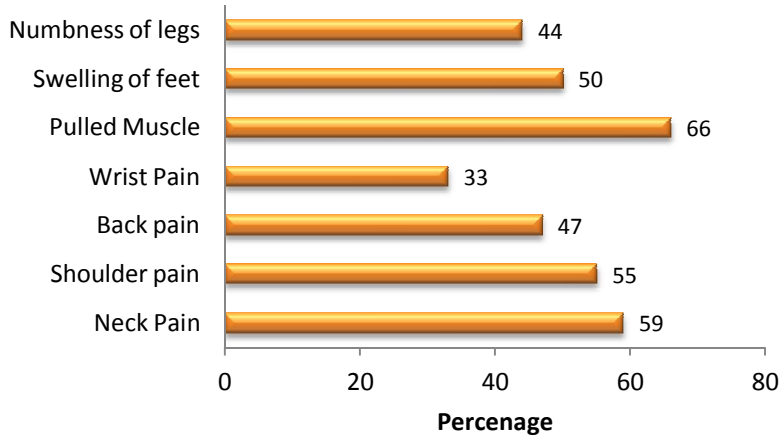

Figure 3: Ergonomic issues faced by photocopy machine operators

Dry mouth (70%), fatigue (79%) and head ache (91%) were frequent among the operators who had been working for 1 to 3 years. Like wise the same health effects were seen, with slight varying percentage in working group of 4 to 6 years. While in 7 – 9 working year group, head ach was experienced by 79 % operators, fatigue by 91% and occurrence of dry mouth, sore throat and respiration irritation were 70 to 78%. 14 out of 14 operators reported it, followed by dry mouth and fatigue (93%). Fatigue (91%), Sore throat (82%) was observed in working group 16 – 18 years but a visible reduction in hearing disturbance (9%) was seen which may be attributed to the acclimation of the operators with the sound of the machine and their surrounding workplace.

Table 12: Descriptive Statistics of the parameters monitored at different photocopy shops (36)

Parameters	Min.	Max	Mean	Std. Dev.
NOISE	59.7	76.3	70.344	3.3732
PM	183	440	306.86	65.345
VOC	0.8	5.9	2.422	1.3312
OZONE	0.30	4.90	1.5447	1.25325
CO	44	90	70.56	11.562
SO_X	39	60	47.19	6.187

Fatigue was the most common and frequent health out come affecting all the working year groups. Poorly organized or excessive working hours, improper working surface and environment can cause fatigue and lead to work-related stress. McBride and Furtaw reported personal exposures increased as the machine operators remained close to the photocopy machine for long durations **[29, 30]**.

Neck pain and back pain was the most frequent ergonomic problem found in operators working from 4 to 6 years on photocopy machine, followed by shoulder pain which was found in 80% operators of the working year 13 to 15 group (Figure 4).

Swelling of feet and numbness of legs were found to be reported highest by the operators working for more than 15 years.

Appropriate ergonomic designs and work shift are necessary to avoid repetitive stress and strain which otherwise results in hand, wrist, back, shoulder pain **[31].**

When the emissions emitted from photocopy machines were related with each other using the Pearson correlation, a strong/ significant correlation was found almost among all the emissions emitted (PM, VOC, Ozone, VOC, CO and Sox) as the Sig. (2- tailed) value was less than 0.005 (Table14).

The figures show that PM_{10} is significantly related with other emissions, however VOC and Ozone didn't showed significant correlation with each other as the p value was greater than 0.005. PM_{10} holds high significant relationship with ozone which is in accordance to the study done by Lee *et al.* in which correlation exists between ozone and particulate matter emitted from copying machine (Table 16) **[3].** PM_{10} also has significant relationship with VOC which is shown by the wok of Destaillats *et al.* that VOCS contribute to particle generation **[32]**.

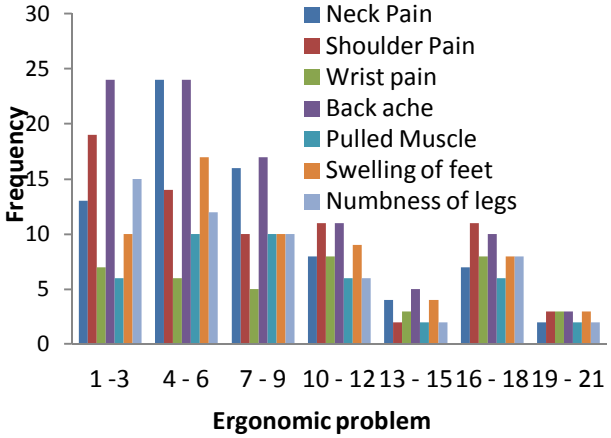

Figure 4: Comparison of Ergonomic problems with Working years of operators

Table 13: Comparison of health effect percentage with working years of operators

HEALTH EFFECTS (Percentage)	**Working (Years)** 1- 3	4 - 6	7 – 9	10 - 12	13 - 15	16 – 18	19 - 21
Dry mouth	70	73	70	93	100	72	66
Sore throat	48	35	74	64	80	82	66
Abdominal cramp	39	40	48	29	60	64	66
Itching	45	38	39	50	20	55	33
Blurred vision	48	51	30	50	20	19	0
Skin rash	9	14	13	14	0	27	33
Dry eyes	48	65	52	49	40	55	33
Respiration irritation	27	32	78	64	60	82	66
Hearing disturbances	51	30	13	14	0	9	0
Fatigue	79	73	91	93	100	91	100
Restlessness	61	46	25	14	20	19	0
Weakness	45	35	61	43	20	45	100
Headache	91	73	79	100	60	54	100
Dehydration	40	24	55	30	40	45	66
Dizziness	54	54	52	57	40	54	33
Mood swings	66	57	22	57	20	18	0
Fainting	9	5	17	21	20	54	100

Table 16: Independent sample test of the photocopy machine emissions for season variation

		Levene's Test for Equality of Variance		t-test for Equality of Means				
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
PM	Equal variances assumed	9.941	.003	-4.170	34	.000	-72.5294	17.39243
	Equal variances not assumed			-4.318	26.898	.000	-72.5294	16.79839
VOC	Equal variances assumed	27.413	.000	-2.532	34	.016	-1.0550	.41667
	Equal variances not assumed			-2.657	21.386	.015	-1.0550	.39709
OZONE	Equal variances assumed	32.474	.000	-4.507	34	.000	-1.5102	.33510
	Equal variances not assumed			-4.755	19.276	.000	-1.5102	.31760
CO	Equal variances assumed	2.948	.095	-5.416	34	.000	-15.5418	2.86941
	Equal variances not assumed			-5.643	24.292	.000	-15.5418	2.75405
SOX	Equal variances assumed	6.527	.015	-7.925	34	.000	-9.8421	1.24195
	Equal variances not assumed			-8.270	23.640	.000	-9.8421	1.19014

Table 14: Pearson co-relation coefficient of the emissions

	PM_{10}	VOC	OZONE	CO	SOx
PM_{10}	1				
VOC	0.525*	1			
O_3	0.582*	0.201	1		
CO	0.735*	0.610*	0.658*	1	
SOx	0.766*	0.644*	0.678*	0.934*	1

* Correlation is significant at the 0.01 level (2-tailed).

Table 15: P value for the photocopy machine emissions

	PM_{10}	VOC	OZONE	CO
VOC	0.001			
OZONE	0.000	0.240		
CO	0.000	0.000	0.000	
SOx	0.000	0.000	0.000	0.000

Comparison between the Emission levels emitted from the photocopy machines during the summers and winter season showed a High significant difference using the P test value (Sig. (2-tailed)) (Table 17).As the p value for PM, Ozone, CO, SOx is < 0.01, the test is highly significant for the difference in emissions between summer and winter, while for VOC the p value is 0.016 which is > 0.005 showing a significant difference of emissions between the two seasons.

Many factors may be responsible for the significant difference between summer and winter. The average operation of the machines, number of machines used may effect the concentration but the most important being the conditions prevalent at the photocopy shops. It has been observed that during summers windows were open, fans and exhausts being frequently used which resulted in air movement and air dilution while in winters no fan and exhaust were operational beside closed windows and doors which resulted in building up concentration of pollutants in the work place of the operators.

Electricity load shedding could have also contributed to the differences in concentration for seasonal variation. As in summer load shedding frequency was greater than winter which resulted in less and discontinuous operation of machines while in winter machine average operations was higher resulting in greater emission generation which is in accordance to the work done by Destaillats *et al.,* that operating mode can influence air circulation and temperature at workplace thus affect the emission rates **[6].**

4. Conclusions

The study concludes that photocopy machine operators are exposed to physical, chemical and ergonomic hazards at work. Noise, particulate matter, carbon monoxide and ergonomics are posing a threat to health and safety of workers at photocopy shops. Average monitored values for Noise is 70.4dBA, PM_{10} 299.7 µg/m^3, VOC 2.42 µg/m^3, Ozone 1.54 µg/m^3, CO 70.56 µg/m^3 and Sox 47.19 µg/m^3. Particulate Matter PM_{10} concentration exceeded the NEQS ambient air quality standard at many photocopy shops with in the study area while Noise level at few shops slightly exceeded the standard limit of 70 dBA.Nabah Road photocopy shops, congested and lacking operational ventilation facilities are the target site as they have high values in almost all the emissions measured.

Statistical Significance analysis done on the emissions emitted showed the p value to be < 0.005 for particulate matter, volatile organic compound, carbon monoxide, oxides of sulfur and ozone emissions form the photocopy machines, thus the emissions are statistically significant.

Dry mouth was most common health issue among the photocopy operatorswhile Fatigue and headache were the most common health outcomes affecting all age groups almost in the same frequency. Ergonomic issue comparison showed that Neck pain and swelling of feet was most frequent while Back pain was most common ergonomic problem affecting all the age groups.

Statistical significant correlation exists between $PM_{10,}$ Ozone, Carbon monoxide, SO_x emitted from the photocopy machine as the Sig. (2- tailed) value was less than 0.005. Emission levels of PM, VOC, ozone, CO, Sox significantly differ during the summer and winter season as the p value for Independent Sample Test of the Emissions for season variation was less than 0.005.

It is recommended that photocopy machine operators should be given occupational health and safety training so that they can recognize hazards and try to prevent the harm caused. Periodic health check up of the operators needs to be done to asses their health conditions.

Work place design must be kept in view to make appropriate work place so as to reduce the work related issues. Ventilation of workplace should be carried out in both summer and winter season to provide adequate air circulation so as to prevent the in building of pollutants at the work place.

Protective measures should be used by the operator while filling the toner cartridge, removing jams from the machine, doing its maintenance etc as these are the instances where he comes into close contact with the toner powder and other hazards. Machine lid should be closed before photocopying as the light does irritates the eyes and may result in visual disturbance or head ache.

Operators should be made aware about the proper working postures which are to be maintained in order to avoid ergonomic problems. Further the work place design, working shift of the operators should be appropriate with sufficient breaks so as to reduce the fatigue and risk of work related musculoskeletal discomfort

Proper and periodic maintenance session of the photocopy machine should be carried out. The person, who has to perform the cleaning and maintenance of the machine, should be give full training and instructions regarding the technical and safety and health aspect.

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