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REVIEW PAPER

Assessment of environmental and ergonomic hazard associated to printing and photocopying: a review

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Abstract "Knowledge is power" and distribution of knowledge is fueled by printing and photocopying industry. Even as printing and photocopying industry have revolutionized the availability of documents and perceptible image quickly at extremely inexpensive and affordable cost, the boon of its revolution has turned into a bane by irresponsible, uncontrolled and extensive use, causing irreversible degradation to not only ecosystem by continuous release of ozone and other volatile organic compounds (VOCs) but also the health of workers occupationally exposed to it. Indoor ozone level due to emission from different photocopying equipment's increases drastically and the condition of other air quality parameters are not different. This situation is particularly sedate in extremely sensitive educational and research industry where sharing of knowledge is extremely important to meet the demands. This work is an attempt to catalogue all the environmental as well as health impacts of printing or photocopying. It has been observed that printing/photocopying operation is a significant factor contributing to indoor air quality degradation, which includes increase in concentration of ozone, VOCs, semi-volatile organic compounds (SVOCs) and heavy metals such as cadmium, selenium, arsenic, zinc, nickel, and other pollutants from photocopy machines. The outcome of this study will empower the manufactures with information regarding ozone and other significant emission, so that their impact can be reduced.

Keywords Printing · Photocopying · Indoor air pollution · Occupational health · Air pollution

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Introduction

"Indoor air pollution" in basic terms is the pollution of air in a confined space, which is a common issue in our daily life. Productive and corrective strategies are earnestly expected to battle the issue of indoor air quality. In recent past, people's concern has grown rapidly over the poor quality of indoor air specially in urban areas where printing and photocopying are more common than in rural area, which causes adverse effects on human health (Haines et al. 2006; Brook et al. 2004). Now a day's air-conditioned buildings in everyday lives are more common in almost all parts of the world and the majority of these are responsible for the recirculation of a high portion of air. The individual lifestyle of building inhabitant, has also altered, these alterations have distorted the type and concentration of chemicals that the people are facing in their homes and offices. However, Office printer and photocopying machine are unavoidable but it has enough potential to degrade human health and indoor air quality due to its close proximity to the worker occupationally using this equipment's at their working location as well as at home which result in higher personal exposure than a nicely mixed building air (Destaillats et al. 2008). In most of the working places, indoor air pollution is extensively distinguished as one of the most grave potential environment hazards to human health as per "WHO Indoor air quality research" (Lee et al. 2001).

Residences, public building or offices are the most common place where people spend most of their time indoor where abundance of indoor air pollutant is most common due to poor ventilation and multiple sources of VOC's (Bruce et al. 2000; Guo et al. 2004). More than half of the respiration done, in this modern scenario, during an individual's life time is air inhaled in these confined spaces, be it home or office (Bruce et al. 2006; Wolkoff 2013). Human beings adapt with the surrounding in which they exist and facilitates a constant gas interchange; making the process of respiration the fundamental passageway of contaminants. The indoor toxins are infinite and their sources are present everywhere (Steinle 2016). Their levels of concentration may change after some time and relics mainly upon the idea of the origin, ventilation, habits and activities completed by the people present in these regions.

Presently due to urbanization and rapid increase in population the number of offices uses fax machine, laser printer, photocopying machine and other electronic gadgets for rapid transfer of information, which releases multiple primary pollutants like VOC's, ozone, SVOC's and particulate matter (AlSumaiti 2013).

It is notable that equipment such as photocopiers and printers radiates several chemicals like ozone, acetone and particulate toner matter. The constituents of toner will respond differently when affected by light and increased temperature because of some complex chemical processes and thus emit these particulate matters (Barrese et al. 2014). Previous research proves the unfriendly impacts of these machines on human well-being and its significance in accordance with the field of Occupational Health and Safety (Bruce et al. 2006; Karrasch et al. 2017). A meticulous study in Aveiro, Portugal, showed continuous estimation of size-segregated particulate matter, total VOCs, O_3, CH_2O, comfort parameters for example temperature and relative humidity as well as carbon monoxide and this research suggested multiple health complications (Pirela et al. 2013; Vicente et al. 2017) in an office environment due to indoor air pollutant.

Electrical devices like laser printers, photocopying machines and ozone generators are the reasons due to which indoor ozone is generally generated (Valuntaite and Girgždiene 2007; Wang et al. 2012). Indoor ozone can also be delivered by the corona release from electrostatic air cleaner machines (Boelter and Davidson 1997). Photocopiers are an essential facility that is being provided in most of the commercial office and educational institution so, even if photocopying is important, it is unfortunately also contributing to ozone emission. Photocopying machine uses a direct supply of electron and the electrostatic drum which is an integral part carry a negative charge produces excess amount of ozone while charging and releasing of the drum (Yan 2013). Several studies have shown the photocopy machine and printers significantly producing both VOC's and ozone (Singh et al. 2014; Khatri et al. 2013). These machines can also emit light in ultraviolet as well as visible range radiation. The fluorescent lamp present inside the photocopier is responsible for ultraviolet radiation (Khatri et al. 2013). In photocopy centers, ozone radiated amid photocopying activity may upgrade the potential danger of health on representatives and guests or customers visiting it.

Throat, eyes and human nostril are more strongly affected due to ozone, and long-duration release from the photocopy machine leads to not only reduced lung functions but also higher stress and systemic inflammation leading to higher risk of cardiovascular diseases (Baughman and Arens 1996).

Previous work (Wilkins et al. 1993) highlights the emission of 60 different type of volatile organic compound from office equipment's like printing and photocopying machine and due to their potential health effect toluene, styrene, ethylbenzene and benzene and their carcinogenic activity (Destaillats et al. 2008; Yu et al. 2004) have attracted much attention for their assessment and management to sustain our growth. Indoor air quality of the place where the photocopier machine functions has been observed poor due the release of the volatile organic compound (VOC) like benzene (Tuomi et al. 2000; Patron et al. 2015). Longer operation of this equipment leads to higher discharge rates of VOCs, SVOCs, ozone and heavy metals per copy due to high chamber temperature (e.g., a 20% increase came due to expanding temperature from 23 to 32 °C) and changing from single-side printing to double-side printing (40% expansion) (Tuomi et al. 2000).

It was also observed that the emission of this VOC depends upon the toner which we are using in the photocopier and it is also observed that the toner which has thickness less than 0.01 has less emission of VOC than others (Wolkoff 1995) mainly O_3. Plus amounts of individual volatile were within recommended maximum exposure limits for a reasonable number of printers in an all-around ventilated office condition (Tuomi et al. 2000).

Several studies have shown that during photocopier operation, ozone and several volatile organic compounds (VOCs) are emitted leading to indoor air quality problems but also affecting occupant's health. Very little study has been done in India to catalogue all the occupational hazard associated to photocopier operation and their mitigation method has even not been touched upon. It is important to affirm whether toner represents a hazard to people or not by a very efficient epidemiological examination. The reason for this investigation is to inspect the connection between printer/copying machine toner-exposed work and respiratory disorder.

Emission from photocopy/printing machine

Photocopy/printing machines are part of everyday environment of millions of people around the world, which make it unavoidable in offices, industries, shops, schools and laboratories. Hence the question of harmful effects of operating this device and what extent does the air is polluted is an important concern of the public (Ewers and Nowak 2006).

Due to increase in the use of printing/photocopying since early 1990s, people are facing the deleterious effect of ozone, for a building without photocopying machines the ambient ozone concentration in 250 times less compared to outside due to filtration through walls; however, due to the use of photocopying machine the indoor ozone concentration becomes significantly high (KAGI et al. 2007b; Patz et al. 2005).

Particulate matter, ozone and volatile organic compounds (VOC) are results of pollution (Mahadevan et al. 1999). Dry process printers have been considered as a significant factor contributing to indoor air quality issues. Cadmium, selenium and arsenic have been reported as other pollutants from photocopy machines (Stefaniak et al. 2000).

Printing machines and printers are the one of the reasons for the presence of ozone in the indoor air along with other anthropogenic sources (Liu et al. 2013). The sources of possible health concerns from the printing machine are carbon black toner, resins of different polymers, O_3, UV light, etc. Ultraviolet radiation can also result in formation of ozone (for example, UV lamps are used in hospitals and industries to ensure sterility from the bacteria). Commercial use of ozone for removing the airborne contaminants can also act as sources of ozone in the indoors. The Lithuanian hygiene standard HN 35:2002 states that the threshold limit value (TLV) for the concentration of ozone in the work area is 200 $\mu g/m^3$ over 8 h exposure (Valuntaite and Girgždiene 2007). Different sources (Matshediso 2014) give the allowable concentration in the work area in 100 $\mu g/m^3$. Ozone is a very unstable compound due to its high reactivity.

The half-life of the ozone lies between 7 and 10 min in indoor environment in normal conditions (Weschler 2000) which can be determined by air exchange and surface removal. Other observation stated (Weschler and Shields 1999) that half-life of ozone in an building is less than 10 min. Rate of emission of hazardous substance and volume of air that dilutes the released substance are the two basic parameters on which the pollutants concentration present in the workplace depends. Emission from the printing/photocopying machine and other electrical devices depends on many factors, the technology standard used, types of machines, operation duration and rate, process conditions, and so on (Benczek et al. 2000).

It has been observed that toner formulations utilized by photocopiers (PC), popularly known as "toner-based printing equipment" (TPE), are nano-enabled products (NEP) in light of the fact that these machines consist of multiple improved nanomaterial (ENM) which enhance the performance of toner (Martin et al. 2017). There is convincing confirmation that the PM0.1 releases from TPE is biologically active and have enough potential for inciting oxidative stress and cancer. It has been observed that, prevalence of wheezing, constant cough, nasal blockage, breathing challenges and shortness of breath among the workers occupationaly exposed to this operation (Khatri et al. 2013). Consequently, cardiovascular, respiratory, immunological and different disorders have also been observed due to prolonged exposure period resulted in “Sick Syndrome” a condition related to multiple illness disorder of workers occupationaly exposed to photocopiers (Smith and Mehta 2003; Pirela et al. 2013).

The fact we need to comprehend is that the danger postured by these machines is prominent and cannot be disregarded. “Indoor air quality” ought to be intended to ensure and enhance the well-being of employees. Despite the fact that work proficiency expanded, it bargained air quality which is not worthy (Elango et al. 2013). It has been proven by research that engaging in activities alongside a printer in operation is equal to breathe in tobacco smoke or to inhale debilitate vapor of congested driving conditions, and for our respiratory system there is no distinction (Barrese et al. 2014).

The toner used in printing and printing/photocopying machine is known to cause respiratory diseases if inhaled or else cause irritation to skin. Ultraviolet radiation used in photocopy machines has the potential to cause harm. These machines use visible and invisible light like UV rays. Risks of having skin cancer are high when humans are exposed to such environment. (Larson and Muller 2002). Particulate matter other emission from this equipment causes respiratory issues, problems to lungs. Systemic inflammation is caused due to such toxic exposures causing a high risk of cardiovascular diseases. Benzene, xylene and toluene are produced from such machines of which benzene and styrene are carcinogens (Lee et al. 2006). Noise pollution is another issue leading to risks of hearing due to high amount of exposure to loud noise of photocopy machines which may lead to fatigue and distraction (Oberdörster and Utell 2002).

The proposed work will focus to analyze the emission from printing/photocopying machine and outcome of this study will provide enough knowledge to the individual occupationally involved in this operation for the acute as well as chronic problems due to VOCs, SVOCs, heavy metals, ozone and other emissions from printing/photocopying machine.

Associated hazards from printing/photocopying machine

Study reveals that there is even emission of the UV radiations because of this photocopier machine and these are also harmful to the person who is taking this as the profession and it also said there is no relation between the emission of the ozone and the UV radiations (Jaakkola and Jaakkola 1999; Singh et al. 2014). Based on the available literature, the following hazards have been observed during various operations of photocopy/printing:

1. Heavy metals
2. VOC
3. Ozone and multiple gases
4. Particulate matter
5. Radiation
6. Temperature.

Sources of heavy metals in air

The intake of heavy or trace metals containing food will be radically reducing some of vital form of vitamins and nutrients from the body that is responsible for reducing substantial metals, which are already present in the earth, because of the naturally occurring and other anthropogenic activities.

People are exposed to the heavy metal, namely arsenic, chromium, barium, lead, selenium, mercury, silver, cadmium, through different pathways (Khan et al. 2008; Martin and Griswold 2009). Humans are always exposed to these heavy metals also called as (trace elements) by either ingestion or inhalation. The wastewater contains large amounts of harmful heavy metals that cause potential problems in the agricultural production (Rattan et al. 2005). Heavy metals presence in the earth and plants pertains to potential harmful human and adverse health effects and the risks associated with it. The food chain contamination has been the most important path as being considered for entry of the specified toxic heavy metals into body of human beings (Khan et al. 2008). Important sources of air pollution are categorized in Fig. 1, and some potential anthropogenic sources has been discussed below.

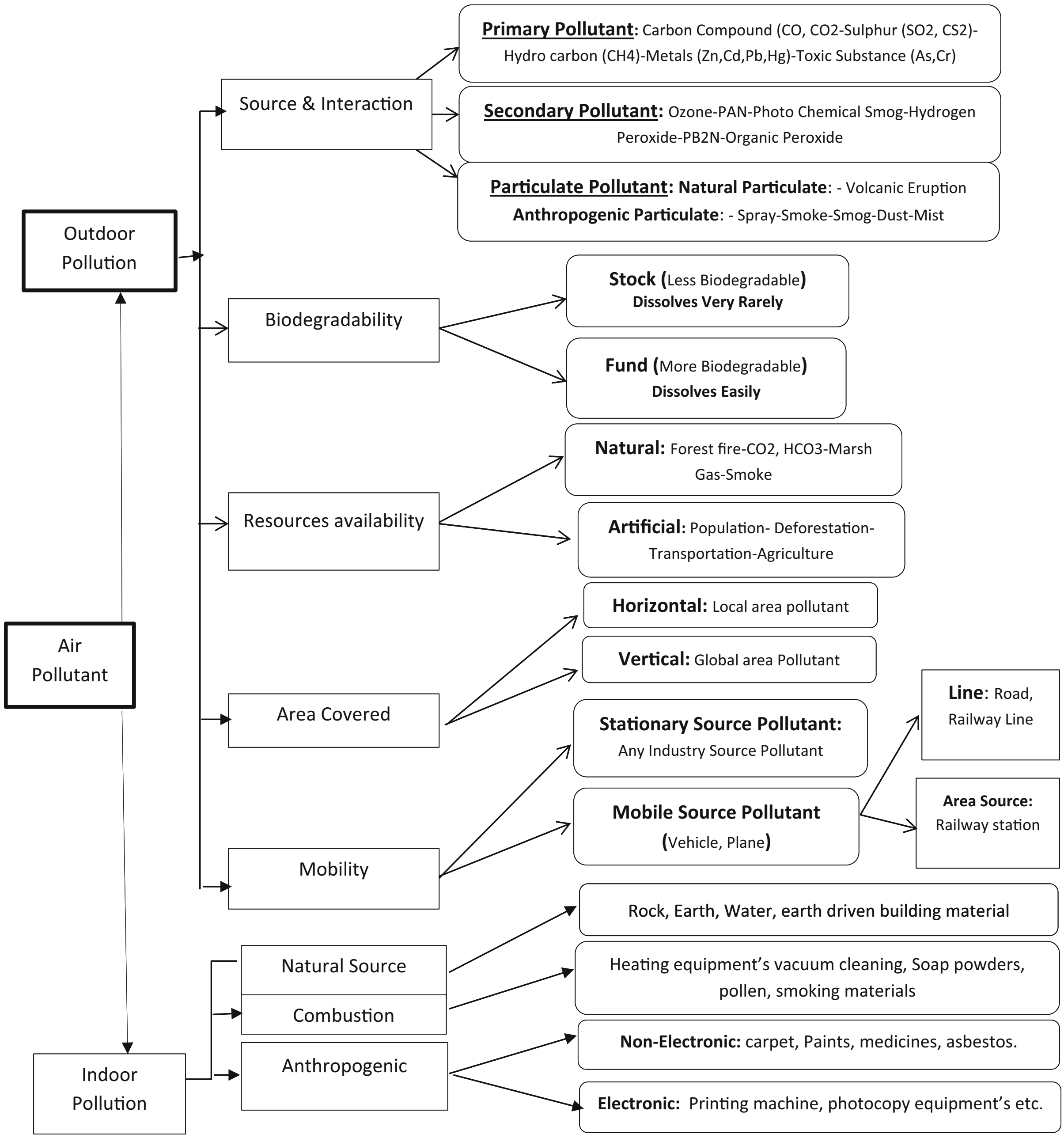

Fig. 1 Different sources of air pollution (Jones 1999; Nazaroff and Nero Jr 1988; Masters and Ela 1991; Stern 2014)

Airborne heavy metals sources

Airborne particles of heavy metals consist a part from the stack of different industries, vehicular emission emission of gas or vapour from waste storage location or solid waste storage sites and multiple anthropogenic activities. Airborne metal particles are mostly discharged as particulates that are in the gaseous form (Smith and Brauning 1995). A few metals Cd, As and Pb can be volatile at extreme temperature while processed. The metals present can change over to oxides and get condensed as small particulate matter unless a reducing type atmosphere is kept over (Wuana and Okieimen 2011).

Urbanization

Urbanization and movement of traffic, mechanical and rural agricultural exercises, waste burning and mining have altogether added to the entering of metal particles through breathing into the human body (Sharma and Agrawal 2005). In the urban atmosphere Co, Cu, Cr, In, Fe, Mo, Ni, As, Cd, Hg and Mn, are present as the most important heavy metals (Smith et al. 1996). Lead and cadmium are highly contained in the urban atmosphere. Other heavy metals Cr, Ni, Cu and Zn concentration are less compared to other trace elements (Purves 2012).

Vehicular traffic

In urban zones, the road dust-related substantial metal contamination emerges from a large number of sources like water transported material, dry and wet conditions of atmospheric deposition, street surface wear, street paint debasement, vehicle wear, vehicular particulate discharges (Banerjee 2003; Sutherland and Tolosa 2000). The areas that are close to the roads which have dense traffic is likely rich in Zn, Pb, Cu and Cd concentration (Krishna and Govil 2007). Discharges coming from street traffic in thickly populated urban areas contribute to increase adverse health effects (Johansson et al. 2009).

Industries and factories

In urban cities, steel plants along with other industrial and mechanical activities, effluent burning plants, foundries and energy generation plants also produces significant amount of heavy metals.

Pesticides

Pesticides contain copper mixture used as fungicidal showers like Bordeaux blend and copper oxychloride. Lead arsenate utilized for organic product plantations to control some parasitic bugs. Arsenic containing mixes are utilized to effectively bring down cattle growing ticks and reduce the other pests in banana plantations. Pesticides and fertilizers of some kind also contain sources of arsenic which can be released into the environment (Martin and Griswold 2009).

Other sources of heavy metals in food chain

Emission factors of streets in the urban area regarding concentration of heavy metals can be estimated using Gaussian dispersion air quality modeling (Johansson et al. 2007). Solid form like pools of Ni, Cu, Cd, Zn, Cr and Pb could be parted into five characterized portions that are interchangeable compounds and also operational, bounded to carbonate compounds, bounded to Fe and Mn oxides, which are bound to natural matter and residue occurring (Banerjee 2003).

Hg, Ag, Pb and Ni are some of the heavy metals that are persistent and bio-accumulative in nature, and do not reduce down into the environment or else is never so easily metabolized (Rattan et al. 2005). These heavy metals get accumulated on to the ecological form of food chain by modes of the uptake through the various trophic levels and initial through the primary producer and after that through the consecutive consumer levels. Heavy metals presence in plants will depend upon the plant species (Khan et al. 2008; Sharma and Agrawal 2005).

Vegetables that are cultivated in the wastewater irrigated soils absorb the heavy metals in much larger amount which is the antecedent for potential harmful health effects to the human beings in the immune system defenses, internal uterus growth problems, impairing mental and the social abilities, disability in relation with the inadequate nutrition and also high chance in the occurrence of the gastro-related intestinal cancer rates (Khan et al. 2008; Martin and Griswold 2009). Drinking water sources when contaminated with heavy metals can lead to major ailments like renal failures, liver cirrhosis, hair fall and hair loss and chronic anemia (Salem et al. 2000).

The heavy metals like the Cd, Ni, arsenic and chromium possess a large count of harmful hazards to the humans (Wintz et al. 2002). Heavy metals are also the prime potential carcinogens. Cadmium (Cd) ingestion causes the itai-itai named syndrome and the mercury (Hg) ingestion causes the Minamata syndrome. Other forms of heavy metals like the arsenic (As) can cause toxic effect in the drinking water. Few of the heavy metals like Cu, Mn, Ni, Mo, Fe, Co and In are called the micronutrients and can be toxic only when taken above the required level (Sharma and Agrawal 2005).

The very essential and important heavy metals like Mo, Cu, Fe, In, Mn do biochemical and many physical function in both the animals and plants. Most important function for the heavy metals include involvement in the reducing and oxidation reaction and the direct involvement due to the important part of the all other enzymes (Nagajyoti et al. 2010).

Copper is a very important heavy metal in higher order plants and the green algae, mostly prime important in the photosynthesis. Cu is the component of primary electron donator in the photosynthesis, known as the copper (Cu) protein plastocyanin. It is due to the Cu which can very reactively oxidize and reduce electron (Sharma and Agrawal 2005). (In) another heavy metal that is present in enzymes such as superoxide dismutase, carbonic anhydrase, the RNA polymerase, alcohol dehydrogenase is necessary to make up the overall structure for the ribosomes. Nickel another content of urease enzyme that is important for the working and also for the good physical health condition in the animals (Sharma and Agrawal 2005).

Lead and Cd have been considered as the potential harmful carcinogenic metals and are related to a many diseases, namely cardiovascular, nervous system, bone, blood and kidney diseases. Dietary form of ingestion is the main path to the harmful exposure to the human beings, even though inhalation can be causing a vital role in contaminated locations (Järup 2003). Hence, the details regarding heavy metal various chemical concentrations and their harmful effects in food products and dietary form ingestion, water intake and other forms of ingestion and inhalation is important method in calculating the threat associated to human being health (Zhuang et al. 2009).

People who work in or live in places which is in close proximity to an industry like photocopy machine and printing, which utilize the metals and its compositions, can lead to increased threat on exposing, or to the people living near to a location where the heavy metals has been unsafely disposed (Martin and Griswold 2009; Salem et al. 2000).

Authors from the previous study suggested the presence of heavy metals in the emissions from photocopy machines and it includes iron, zinc, nickel, chromium, arsenic and cadmium (Barthel et al. 2011; Ibrahim et al. 2006; Martin et al. 2015) and exposure to these pollutants leads to adverse health effects. The lifetime cancer risks premature aging, irritation to eyes, headaches are major risk to health (Wolkoff et al. 1993). Maintenance personnel are exposed to toner powder at the time of maintenance rather than pollutants emitted during the photocopying operation (Kasi et al. 2017).

Heavy metals from printing and photocopying machine

Following different heavy metals emissions from photocopy and printing machine has been observed in past studies, which has adverse effect on health safety and environment:

- Arsenic
- Barium
- Cadmium
- Chromium
- Zinc
- Nickel
- Iron.

Arsenic: emission from photocopier and its effect on health safety and environment

Arsenic is discharged in bigger amounts through volcanic action, disintegration of mineral rock deposits, timberland flames and manmade action. The wooden industry that preserves wood utilizes a majority of the industrial arsenic. It's also found in paints, various drugs, metals, semiconductors and soaps. Other sources include copper and lead smelting, mining operations or coal combustion (Martin and Griswold 2009). Arsenic is very toxic in nature and its exposure to human and animals can lead to various dieses. Arsenic may occur in two forms, namely organic form and inorganic form (Lauwerys and Hoet 2001). There are many manmade sources of arsenic such as smelting of metals, combustion of coal and burning of waste. However, elemental analysis of toner powder of printer revealed the presence of arsenic (As) at respectable particle size of 2.4 $\mu g/m^3$, while monitoring the indoor air quality at different photocopier center, it was found that the concentration of arsenic was within the Indian ambient air standards (Elango et al. 2013; Könczöl et al. 2013) and it can be absorbed by ingestion or inhalation as it is present in toner powder (Graeme and Pollack 1998).

Health effects

It is a cancer-causing agent and can cause skin-related cancer, urinary bladder, lungs and liver-associated cancers also, very low level of exposure to the arsenic can cause vomiting and nausea, reduction in the of red platelets and white platelets, abnormality in the heart rate, harm in the blood vessels, pin as well as needle effects in the hand and foots, darkening on skin and visible presence of small corn on the inner and outer sides of palms (Martin and Griswold 2009; Hughes 2002).

Regulatory limits

For drinking water, the recommended limit is 0.01 ppm according to the Environmental Protection Agency (EPA). TWA (time weighted average limit) as per OSHA (Occupational Safety and Health Administration) is 10 $\mu g/m^3$ which is calculated for 8 h per shift and 40 h a week in workplace (Martin and Griswold 2009; Welch et al. 1982).

Barium

Barium mixes, like barium–nickel compounds, are utilized for spark plugs in vehicles and to vacuum tubes, oxygen-expelling chemical reagents, barium sulfide is utilized as a part of fluorescent lights, barium sulfate is utilized as a part of indicative medicine, barium nitrate and its chlorate form is used to give firecrackers a green coloring. Barium mixes are utilized for penetrating muds, paint, blocks, ceramics production, glass and industrial rubber (Morais et al. 2012; Martin and Griswold 2009). The persons working with photocopying machines and printers have been effected with the increased basal DNA loss due to the usage of the particulate matters of below 2.5 and toners using harmful chemicals like barium sulfate and other organic (Martin et al. 2015). At the point when the machine is in task, the DNA repair process had demonstrated a colossal increment in first but later it proved to be the decrease in the DNA mechanism which shows the effect of the chemicals like barium sulfate, organic compound and radiation on the DNA of the people (Goud et al. 2001).

Health effects

Mild exposure to the barium can cause vomiting, abdominal-related cramps, problems while breathing, blood pressure variations, weaknesses of muscles (Martin and Griswold 2009). Large exposure of barium concentration can lead to increased blood pressure and heart rate changes and abnormality and possible fatality (Judd and Levy 1991).

Regulatory limits

As per EPA, it is 2 ppm for drinking water (Martin and Griswold 2009). OSHA standard is set to 0.5 mg/m^3 TWA which is calculated for 8 h per shift and 40 h a week in workplace.

Cadmium

Cd is one of the poisonous metals which we shall find in industrial workplaces has significant hazards effect on health and environment due to its overexposures. In printing/photocopy machines, most of the heavy metals like cadmium, chromium, arsenic, lead are used as pigment coloring materials and other sources are rechargeable batteries, printer drums, toners, printer's inks and cathode ray tube screens, etc. (Stockmayer 1956). The photoconductive material in photocopy machine is generally Cd, and some photocopy machine uses a drum impregnated with cadmium sulfide (Vertegaal and Anselrode 1980). In earlier studies, cadmium and cadmium compound exposure from the copying process have been reported as 0.2 micrograms per cubic meter (Kalimeri et al. 2017).

Health effects

Smokers get presented to more cadmium intake levels than non-smokers. Cadmium and its mixes are cancer-causing agents (Järup et al. 1998). The lungs may be seriously harmed by inhaling abnormal amounts of cadmium. Ingestion of abnormal states seriously bothers the stomach and can lead to puking and loose bowels. Long-duration presentation to lower levels prompts to development inside kidneys and conceivable kidney sickness, lung harm, what's more, delicate bones (Kampa and Castanas 2008; Satarug and Moore 2004). The gas released from materials especially when it is become hot can cause throat irritation and major risk involves for staff while cleaning or grinding the surface of the printer drum. The exposure to cadmium fumes causes flu traces that cause weakness, headache, sweating, chills and musculoskeletal disorder (MSD). The main health risks due to continuous exposure are lung cancer and damage in kidney. Cadmium presence is also resulted to cause bone disease such as osteoporosis and pulmonary emphysema (Razak and Ismail 2017).

Regulatory limits

EPA describes 5 parts for each billion [ppb], i.e., 0.005 (ppm) of cadmium as limit for water for consuming. Food and Drug Administration [FDA] focuses on packaged water for drinking that should not surpass 0.005 ppm. Occupational Safety and Health Administration standard mentions a normal of 5 $\mu g/m^3$ for an 8-h workday, 40-h work per week (García-Rico et al. 2007).

Chromium

Cr mainly originates from mineral rocks, flora and fauna and in soil and is present in all the three states of matter. Chromium is utilized as a part of metal amalgams, stainless steel, electroplating, producing magnetic-coated tapes, and paints, bond, paper, elastic, in synthesis floor material covering dissolvable forms are utilized as a part of wood additives (Barnhart 1997).

Chromium used in printing inks are in various forms such as Chrome Yellow (3.2-1)PbCrO4, Molybdate Orange (25)PbCrO4, Chromium Green (Langård 2013). Chromium is considered as atmospheric toxant due to its wide industrial use. Chromium toxicity depends on valency state; Cr(6) is highly poisonous than Cr(3) (Gadhia et al. 2005). Photocopiers can lead to health hazards due to atmospheric exposure to radiation in RF range of 100 kHz–300 GHz, at field strengths lower to these require to create thermal effects. Maximum exposure of magnetic field is usually 200 mg. Studies shows that magnetic field limit in occupational and residential areas lies between 0.2 and 0.3 (2.5 mg) which is more hazardous than electric field (Férey et al. 2005).

Health effects

Cr and its mixes are poisons and known human cancer-causing agents, though Chromium(III) is a basic supplement. Breathing abnormal states can make disturbance the coating of nose, runny nose, breathing issues, asthma, hack and nose ulcers (Rowbotham et al. 2000). Contact on the skin can bring about skin ulcers. Unfavorable susceptibility causes skin redness and swelling. Long-term introduction can make harm liver, nerve tissues and kidney circulatory (Shanker and Venkateswarlu 2011).

Regulatory limits

EPA mentions 0.1 ppm in water used for drinking. FDA—ought not to surpass 1 mg for every liter (1 ppm) in filtered water. OSHA mentions a normal of in the vicinity of 0.0005 and 1.0 mg/m^3 of working environment air for a 8-h workday, 40 h of work in a week, contingent upon the compound (Baral and Engelken 2002).

Lead

Petroleum derivative consuming, assembling and mining, lead and its mixes could be found. This incorporates air, soil and water. It is utilized to create batteries, ammo, metal items like weld, funnels and X-ray protecting gadgets (Ziegfeld 1964). Lead is a profoundly harmful metal because of its utilization in a few items like fuel, paints and pipe weld. Water pipes in more established homes, lead in specific beauty care products and toys, and lead-coated ceramics (Chakraborty 2014).

Health effects

EPA mentions it as a human cancer-causing agent. Lead has the toxicity to influence each organ and framework in the body. Prolong introduction of grown-ups bring about diminished execution of the sensory system; shortcoming in fingers, lower legs, wrists, little increments in circulatory strain and paleness (Needleman and Bellinger 1991). Prolonged susceptivity to high lead concentrations may extremely harm the cerebrum and affect kidneys and eventually cause fatality. In ladies who are expecting, abnormal amounts of introduction to Pb may bring about unsuccessful delivery and higher level introduction in men can harm the organs in charge of sperm creation (Needleman 1991).

Regulatory limits

According EPA, lead has regulatory limit of 15 parts per billion in drinking water and 0.15µgm for each m^3 in air (Buringh and Lanting 1991).

Mercury

Heavy metals like mercury, cadmium, arsenic, chromium, thallium and lead are metals having high densities, atomic weight or atomic number. Some heavy metals are useful like iron, cobalt and zinc but can also be toxic if consumed in large amount. High-pressure mercury light is used in projectors and another type of similar light source, or high-pressure mercury light is used in photocopy machines (Han et al. 2001).

Health effects

Mercuric chloride and methyl mercury has been verified as conceivable human cancer-causing agents as per EPA. Mercury is extremely sensitive to nervous system. Exposure to abnormal states can forever harm the brain, kidneys and creating fetuses. Consequences for brain working may bring about crabbiness, bashfulness, and tremors, vision-related problems, hearing disorders and can also cause memory issues. Short-term introduction to abnormal amounts of mercury vapors may bring about lung harm, queasiness, vomiting, looseness of the bowels, increments in circulatory strain or heart rate, infection in skin.

Regulatory limits

EPA describes 2 ppb in drinking water. FDA describes 1 ppm of methyl mercury of fish. OSHA describes 0.1 mg of natural mercury per meter cube of work environment air and 0.05 mg for each meter cube of metallic mercury vapor for 8-h shifts and 40-h work week (Bell Jr et al. 1973).

Zinc and some other elements

Zinc is an integral part of multiple proces industries and it is primarily used in industrial processes that deals with galvanization. Zinc is essential element for the diet, at the same time too much zinc is harmful to health. The zinc inhalation can cause metal fume fever (Ibrahim et al. 2006), and products of zinc stearate have been observed during photocopy operation.

In toners, most abundant element found is iron (0.9–4.2%) and then titanium followed (0.05–0.09%). It was also found that the element composition changes from color to color and manufactures to manufactures (Martin et al. 2015).

Health effects

The most commonly occurring health effects is metal fume fever (MFF) that is mainly caused due to the intake of fresh metal fumes containing zinc oxide with size of the particle < 1 µm. It affects several organs of our body (Murakami and Hirano 2008). The main side effects include lethargy, neuronal deficits, respiratory tract infection leading to disorders on inhalation of zinc smoke, MFF, nausea, high risk of prostate cancer, epigastric or gastro-related problems (Plum et al. 2010).

Regulatory limits

Compared to the cadmium, lead and mercury, the LD50 value for Zinc is very much higher making the element less toxic than the other trace elements. LD50 value for humans is 3 g/kg of body weight (Fraga 2005). The admissible intake restrain as indicated by the OSHA standard is 5 mg/m^3 for ZnO (metal fumes along with dust particles) in work environment air amid an 8-h workday, 40-h work week (Murakami and Hirano 2008).

Nickel

In printers, the documents are read and printed using a laser beam. These types of machines use charging rollers to shift the toner to the paper, while shifting the toner it get emitted to the atmosphere (Lee et al. 2001). Toner dust may be spilled inside the machine which passes into the room through fans and also due to human carelessness (Martin and Griswold 2009). For the average person, inhalation accounts for approximately 0.1–1 μg nickel daily who is working in these industries (Tischner and Nickel 2003). Some of the main routes of exposure to nickel are inhalation, dermal contact and gastrointestinal ingestion (Ilychova and Zaridze 2012). The nickel exposure may cause lung cancer, also affect liver and kidney (Leovic et al. 1996).

Health effects

Inhalation of the nickel fumes affects the respiratory track and the immune defense system of our body. It is responsible for allergic diseases on dermal contact (Karar et al. 2006). High sensitivity of nickel also causes asthma, inflammation and conjunctivitis (Bates 2010). It is also a potential cancer-causing agent, mainly due to the release from anthropogenic sources (Sunderman et al. 1988).

Regulatory limits

The TLV limit as per OSHA for metallic nickel is 1.5 mg/m^3 and 0.2 mg/m^3 nickel in water insoluble types of organic compounds, for water soluble types 0.1 mg/m^3, 0.35 mg/m^3 for nickel carbonyl type. TWA for metallic nickel is 0.5 mg/m^3 (Bates 2010).

VOC from photocopy/printing machine and its health impacts

Volatile organic compounds are broadly categorized of organic compounds which we have exposed regularly and at room temperature at high vapor pressure. VOCs are emissions in gaseous form originating from some definite type of solid; VOCs consist of different type of chemicals, out of which few may affect the human health on short-term or long-term basis. Building materials, furniture, cosmetics and cleaning products are some of the potential sources of VOCs. As there are numerous VOCs present in the environment, the exact health effects to the exposure is still unknown. Some of the adverse health effects include cancer, sensory irritation and respiratory symptoms. The quality of the air we breathe plays an important role in our health, and the primary exposure to VOCs is through breathing. Emissions from vehicles, industries, factories as well as indoor environments like office and home have become vital source of exposure to a large range of VOCs (Rumchev et al. 2007). However, it is seen that outdoor has more VOC concentration compared to indoors. Emission of VOCs and (TVOCs) is from a wide range of products and printing/photocopy machine is a major source (Leovic et al. 1996; Destaillats et al. 2008; Wolkoff et al. 1993; Sarkhosh et al. 2012). Earlier studies suggest higher concentration of VOC and TVOC inside a building with photocopy/printing machine than a building without photocopy machine (Leovic et al. 1996; Lee et al. 2001).

The toxic change of VOC is the prominent variations caused by VOCs on a person as compared to a person who is not exposed. Apart from the common health effects of VOC, there are some special health effects which include effects on the immune system, visual or auditory defects, apathy, compulsive behavior, memory loss (Mølhave 1991), As VOCs are frequent air pollutants, buildings and furniture materials emit VOCs and pollutants which includes VOCs from outside are transported by ventilation to the inside environment and hence the system of ventilation is also a volatile organic compounds source (Mølhave and Nielsen 1992). Maintenance activities, cleaning activities smoking, spray cans, printing machines, glue, paints and preservatives are also major sources of VOCs which may result in improper respiratory system that are chronic (Ware et al. 1993). VOCs are the important category of chemicals that occur in air that is in indoor environment (Wilkes et al. 1992). VOCs are classified on the basis of boiling point, the most common is BTXS (benzene, toluene, styrene, xylene and limonene (terpenes). Their volatile character and their uses in household things waxes, varnishes, paints, cleaning products, solvents, detergents, etc., are the reason of their broad occurrences (Sarigiannis et al. 2011).

Benzene is widely used in toner of printing machine/photocopier (Grushkin and Sacripante 1994), varnishes, thinners, paints and gasoline as industrial solvents (Holmberg and Lundberg 1985). It is used as a raw material during the synthesis of phenol, styrene, aniline and alkyl benzenes for manufacturing various detergents, resins, plastics and sources also include emissions of consumer products, smoking and burning (Zuraimi et al. 2006). Toluene or methylbenzene is used in a wide range of toner (Burness et al. 1978), household products which include cleaning agents, paints, coatings, thinners, adhesives as solvent. Benzene is also used to increase the octane value in petroleum industry (Sarigiannis et al. 2011; Kotzias et al. 2005). It is highly emitted in hospitals due to the use of disinfectants and cleaning products (Eberlein-König et al. 2002). Xylene or dimethylbenzene is a hydrocarbon which is aromatic. Xylene is used as solvents in the chemical industry for products which includes paints, dyes, adhesives, detergents, pharmaceuticals. Xylene is also emitted from smoking (Kotzias et al. 2004). Styrene is a volatile organic compound that is widely used. Styrene has double bond and is able to polymerize (Sarigiannis et al. 2011). It is used in a wide number of products. The styrene-butadiene rubber and the styrene-butadiene latex in household products are the main components from which styrene is emitted. It is also emitted from smoking (Katsoyiannis et al. 2008).

VVOCs are significant group of pollutants that are found indoor and they spread over a wide range of chemical substances (Salthammer 2016). Some VOCS result due to chemical reactions, some from products that are used indoors and some results as reactive predecessors from secondary products (Chin et al. 2014; Salthammer 2016). VVOCs act a vital role for the evaluation of the quality of indoor air (Loughlin et al. 2011; Salthammer 2016).

There are several possibilities and different sources of very volatile organic compounds. The unsaturated organic compounds reactions may give rise to VVOCs (Rothweiler et al. 1992). Some VVOCs like methanol, ethanol, formaldehyde, acetaldehyde, formic acid are the result of biogenic emissions (Zhang et al. 1994). Human activities such as printing, cooking, baking; heating of glycerin containing foods are also significant sources of VVOCs (WHO 1989; Salthammer 2016). VVOCs are also present in paints, adhesives, cleaning materials, waxes and other chemical products (Chin et al. 2014; Salthammer 2016). Wood, paper and wood composites also contain several types of VVOCs such as acetaldehyde and ethanol (Dodson et al. 2014).

Contact to very volatile organic compounds (VOCs) can result in several health effects. High concentrations of CO2 (more than 15%) lead to headache and fatigue (Morrison 2010). Naphthalene causes major toxic effects such as hemolytic anemia, jaundice and ocular effects (Rothweiler et al. 1992). Some other toxic effects from VVOCs are cataract, eye irritation, nasal irritation, optical neuritis, mold growth, burning eyes, allergic reaction (Rothweiler et al. 1992; Chin et al. 2014; Salthammer 2016).

SVOCs are chemical substances that are used in building materials or other consumer products (Blanchard et al. 2014b). SVOCs are contaminants that arise from different sources and are partitioned to several compartments like gas or settled dust (Blanchard et al. 2014a). They are found in gaseous or condensed phase and are redistributed from the original source to the air of indoor environment (Dodson et al. 2014).

Semi-volatile organic compounds have several sources which include chemical compounds such as paints, adhesives, disinfectants, electronic products, cleaning agents, flame retardants, plasticizers, products of personal care (Weschler et al. 2008; Weschler and Nazaroff 2010). Consumer products and building additives are also sources of SVOCs (Xu and Little 2006).

The health effects associated with semi-volatile organic compounds are nausea, headache, eye irritation, throat irritation, loss in coordination, cancer, kidney damage, liver damage, shortness of breathing, harm to the nervous system, skin problems (Blanchard et al. 2014a; Dodson et al. 2014; Hasan et al. 2013; Hsu et al. 2012).

Ozone and multiple gas during photocopy operation

In a current well-controlled work environment, the worsening of respiratory issues associated to toner's dust contact was least possible to happen, particularly whether the powered toner was cautiously handled but to accumulate more epidemiological proof on the biological effects of toner's dust breathing is important if possible using a longitudinal study design (Nakadate et al. 2006). With different printing speeds of the commercial color printers, the correlation was found that printing is directly proportional to average mobility equivalent particle diameter but inversely proportional to average particle number concentration (Byeon and Kim 2012).

Indoor air quality is influenced by the very reactive ozone gas indirectly as a result of the reaction involving high molecular VOCs where organic acid, free radicals and aldehydes are formed. When ozone reacts with unsaturated aerosol-associated compounds, it produces both volatile and nonvolatile products. As the space inside the printers is very small, the concentration of ozone inside the printers is found to be quite high during printing (Wang et al. 2012). In the laser printing operation, huge amounts of VOCs are discharged to atmosphere. Since ozone concentration trend is found to be inversely proportional to that of total organic compounds, this behavior has led to the confirmation of the existence of reactions between ozone and organic compound (Castellano et al. 2012).

During photocopying process, a larger part of ozone is created, while the drum and paper is being charged and released. Ultraviolet emission from the photocopier lamp also produces ozone (Vicente et al. 2017). In laser printer, styrene and ozone were found, and in inkjet, alcohol was detected. (Kagi et al. 2007a). Production of ozone is incident during many printing activities where emission of UV radiations occurs, during curing of printing inks, use of projection lamps, varnishes, lacquers, etc. (Kiurski et al. 2012c).

Currently, concentration levels for ozone as per OSHA standard for residential buildings are fixed at 0.10 ppm (Lee et al. 2001). It is probably the first ever attempt made by the author to catalogue the adverse effects of ozone release from photocopy machines and printing machine where he found that ozone content after emission was between 30.0 and 60.0 ppb at a certain distance from the printing machine (Ayotamuno et al. 2013). But (Valuntaite and Girgždiene 2007) found the ultimate ozone emission as 94 $\mu g/m^3$ (47.0 ppb) at a distance of 0.5 m from the machines. In the recent years, studies have shown that concentrations of certain gases in the atmosphere indicate that their level exceeds the value of the OSHA and NIOSH standards (Kiurski et al. 2013). The level of ozone accumulated in confined rooms exceeds the Occupational Exposure Standard (Kiurski et al. 2012c). Results from the experiment reflect that concentrations of the ambient ozone are directly related to total volatile organic compounds conc. and significant utilization of ultraviolet (UV) lamps during screen and digital printing operation. 0.05 ppm is the maximum allowable concentration of ozone (Kiurski et al. 2012a).

Ozone and particulate matter are linked to occupational side effects like throat, eyes, nose irritation, headache and fatigue (Massey and Taneja 2011). Laser printers and photocopy machines can sometime emit ozone in small amounts and if it is there in adequate amounts, can cause irritation in the lungs, nasal passage, throat and eyes of employees and visitors. It was calculated that there can be an increment in risk of death by 4% if approximately a 0.01 ppm is the level of ozone increases. Theegarten et al. (2010) confirmed that the female staff in a workplace is more prone to diarrhea and weight reduction as side effects of emissions from these electronic equipments.

Author also observed that variation in the level of ozone relay on type of chemical composition and printing processes used as raw material, various ventilation systems installed in environmental condition and printing machine. Ozone has much higher effect on human health as compared to VOC's (Kiurski et al. 2016a). Several factors like gender, age, smoking, disease, genetic, nutritional status variation may lead to different health effects of exposure of ozone (Ayotamuno et al. 2013). It has been found that ozone at ground level is not environment friendly whether outdoor or indoor. Troposphere ozone is in direct contact with flora and fauna, and it causes damage to the surface tissue of animals and plants and is also harmful to human respiratory system (Kiurski et al. 2011).

Some of the measures that are needed to be taken to counter, cope and reduce the harmful effects of ozone emitted from printers and photocopy machines include room supposed to be properly ventilated so as to let the fresh air in and increase dilution; the lid of the photocopy machine should be kept completely closed and a gas mask should be worn by operators at all times to avoid exposure to harmful gases emitting from the machines. Awareness of ozone gas and its implicit cause and harmful effect on human and environment has to be made among the user of laser printers and photocopy machines. In addition to this, there should be rotation of task among workers so as to avoid continuous and prolonged exposure (Singh et al. 2014).

Based on the various printing processes the concentration of O_3 varies. Variations are associated to combination of chemicals like used natural substances, environmental situations and air exhaust system within the photocopier mechanism. The individual impacts of ozone on human well-being are significantly higher than the individual impacts of VOCs (Kiurski et al. 2016a). Gases such as fine particles, various VOCs, ozone and ultrafine materials are let out into air (Tang et al. 2012).

Ozone reactions with aerosol-related particles lead to the generation of both nonvolatile and volatile particles. Due to the little area inside photocopier, the concentration of ozone inside photocopier is elevated while working with them (Wang et al. 2012). Very high rate of organic compound is thrown out during the laser printing procedure. As the ozone concentration scenario is not directly related to that of total organic compounds, this character seems to strengthen the presence of reactions between O_3 and organic compounds (Castellano et al. 2012).

Printing procedure produces ultrafine powders, volatile organic compounds and ozone. Substances like this led to various bad effects to human body and environment. Therefore, it is a must to eradicate the problems of emitted particles and attaining complete secure assessment on printing procedure (Bai et al. 2010). Concentration of ozone increases with rise of VOCs concentration (Kiurski et al. 2012b).

Photocopiers and laser printer generate less ozone quantities which, if exist in enough amount, can aggravate the lungs, eyes, nasal and throat cavities of workers and other staffs. When there is a 0.01 raise in ppm, there is a raise in risk of fatality by 4–5%. The larger part of the ozone in photocopier get discharged when the releasing and charging of the paper and drum happens. UV emissions from the photocopying light also produce ozone (Vicente et al. 2017). Particulate matter and ozone are related with problems such as throat, nose or eye vexation, tiredness and headache (Massey and Taneja 2011).

In the tropospheric level of the air, ozone is a tricky poison; however, in the stratospheric level it pieces aperture of perilous bright beams to the Earth. Without stratospheric ozone, life on Earth would not have been practicable. Tropospheric ozone is in coordinate association with living creatures, hurting the surface tissue of plants and creatures, and it is harming to human well-being (respiratory framework) (Kiurski et al. 2011).

More and more exposure to elevated ozone dosage results initially in an increased pulmonary function response within 12–48 h but after 3–5 days of exposure cause a diminished pulmonary function responsiveness (Kampa and Castanas 2008). Prior venture to eliminate contaminants has embraced particulate filters, ozone filters and aldehyde filters, in association with cooling fans, ductwork and temperature indicators. Catalytic filters are also frequently used to perish ozone within ozone filled air from charging subsystems into non-toxic materials (Pitas et al. 2011).

The laser printer and photocopier users should be well informed about gases like ozone and their possible damaging effects. The present OSHA value for the level of ozone in inhabited buildings is 0.10 ppm (Lee et al. 2001). Numerous components, for example, age, sex, malady, wholesome level, smoking and hereditary change may confer to the well-being impacts of O_3 presentation (Ayotamuno et al. 2013). In the presence of (NOx), secondary contaminants, such as O_3, aldehydes, nitrates, can also be easily produced (Prica et al.).

Ozone is generated during many printing procedures, whereas UV radiation is produced, during curing of printing inks, varnishes, lacquers, use of projection lights, etc. The level of ozone collected in insufficiently ventilated rooms exceeds the Occupational Exposure Standards (OES) (Kiurski et al. 2012c). Results of experiments tell that concentrations of ozone increase with raise of volatile organic compounds level and high usage of ultraviolet bulbs throughout screen and digital printing methods. The utmost allowable level of O_3 present in workplace is 0.05 ppm (Kiurski et al. 2012a).

Ozone has affinity to absorb heat and it increases the temperature of surrounding. The exposure to VOC's will increase as the temperature increases and lead to acute as well as chronic health problems. UV and infrared radiations increase the temperature of surrounding which in turn adds up heat into the room with heat released by machine during operation and various external factors. When size of room is small and no proper ventilation is provided or no air condition is installed in room, the temperature of room gradually increases. UV absorption analyzer was used to measure presence of O_3 in the surrounding air. The amount of ozone helped to calculate the change in temperature (Papadimitriou 2004). Photocopy machine such as adequate ventilation, fresh air in room, sufficient dilution in room, use of gas mask when multiple machines are operating simultaneously, repeated exposure should be prevented. Wolkoff, Wilkins et al. observed that 60 various VOCs are produced during dealing with photocopying (Wolkoff et al. 1993). VOC emission rates increased with chamber temperature. The highest rates emission was ethylbenzene (28,000 µg/h), 2-ethyl-hexanol (14,000 µg/h) xylene (29,000 µg/h) and styrene (12,000 µg/h). Toluene being the highest concentration in BETXS (benzene, toluene, ethylbenzene, xylenes and styrene) (Leovic et al. 1996).

Mostly indoor ozone producing devices are photocopier machine, ozone generators, laser printers and other electrical devices (Valuntaite and Girgždiene 2007; Wang et al. 2012). Indoor ozone is furthermore conveyed by the corona discharge from electrostatic air cleaner contraptions (Boelter and Davidson 1997). Photocopiers are an important utility in commercial offices as well as educational institutions. Inspiring all of its importance, it also acts as a source of emission of ozone. Printer utilizes a negative direct current process with the electrostatic drum passing on a negative charge which produces enormous measure of ozone in the midst of the charging and discharging of the drum (Yan 2013). Many studies already states that photocopiers and printers are accounted for O_3 emission as well as VOCs (Singh et al. 2014; Khatri et al. 2013). Emission of ultraviolet and visible range radiation comes from photocopier machines. Fluorescent lamp acts as a source of UV radiation in photocopier (Khatri et al. 2013). Emission of ozone while photocopying operation increases the implicit risk of bad health on visitors and employees in photocopy centers.

It is perceived that the impacts of ozone on human eyes, nostril and throat are considerably more grounded than any other pollutant. Long-term introduction to outflows from printers was related to diminished lung work, as well as brought about high oxidative pressure and systemic inflammation prompting high danger of cardiovascular sicknesses (Baughman and Arens 1996).

Particulate matter from photocopy machine

Toners have thermoplastic polymers of tiny particles, and its diameter varies in the range of 2–10 µm with an average of 5 µm. These are grouped as fine dust (analogue PM 10) yet not as nanoparticles. When inhaling even small amount of toner, person with existing in most situations developed unspecified bronchial or nasal hypersensitivity could build up symptoms like sternutation, cough, rhinitis and whistling breathing and rhonchus (Ewers and Nowak 2006).

Sarcoidosis is associated with consistently utilizing a printer and regularly changing scanner toner or doing printer support, and it has been observed that scanner toner in small quantity might act as formerly unidentified antigen in the pathophysiology of a few patients determined to have Sarcoidosis (Rybicki et al. 2004).

Radiation and temperature during photocopy operation

Temperature is one of the major hazards when printing/photocopy machines are operated. Photocopy machines look harmless but they are not, and these machines work using xerograph which involves application of heat or high voltage on tonner which releases the color (Weldman et al. 1993). UV and infrared radiations increase the temperature of surrounding which in turn adds up heat into the room. When size of room is small and no proper ventilation is provided or no air condition is installed in room, the temperature of room gradually increases (Singh et al. 2014). During operation of photocopying machine, it was found that as the level of ozone, VOC’s, infrared and UV radiations and working time of machine increased the temperature of room increased with time (Hansen and Andersen 1986). Since this experiment was done in small size room with glass door and window with no air condition, the operators were facing discomfort while working.

Long-term exposure temperature above 35 °C affects sperm production which affects personal life. When the machine is operated for long time, the glass panel of the machine gets heated up which can cause minor burn. Increasing temperature even causes headache and even reduce performance of operator.

Indoor air contamination has turned into a noteworthy worry in the current decades. In spite of the fact that the majority of the general population are unaware about this term, many of them are becoming prey to this deadly pollution day by day. Pollutants which are present in the inside room atmosphere are said to cause numerous health problems which include throat infection, suffocation and other respiratory diseases (Jalaludin et al. 2014). Some surveys conducted in the past years show many reasons for indoor pollution. Among them, the main contributors are the radiation from electronic machines used in the indoor environment such as printers and photocopy machines (Singh et al. 2014).

Radiation can be known as an energy which is produced from unstable atoms or are produced by machines. Radiation also means that to an emitted energy that travels as electromagnetic waves, radiation has different forms and sources; visible light and sound are the most familiar forms of radiation. Others are ultraviolet light, microwaves, gas flaring, television signals, infrared (a form of heat energy) and photocopiers (Godwin and Reginald 2017).

The copying technology has helped the mankind in easy information transfer and saved the many useful productive man hours. The photocopying machine works on intermediary light conduction process. In this process, the UV light is allowed to pass through the original document, which copies the content and is printed on the separate paper giving us the exact copy of the original document. (Kiurski et al. 2016b).

High-energy operations are required to produce the flash which is required in photocopying process. Huge amount of energy is spent, which results in high amount of radiation. Sometimes this radiation can lead to partial disintegration of toner elements which can cause serious breathing problems once inhaled (Waschk et al. 1980).

Frame shift diseases are caused by prolonged exposure to radiation resulting in the harmful mutation of human genes. DNA damage and several other disorders are reported in persons who are exposed to these radiations for a prolonged period (Goud et al. 2004). The harmful particles that make entry into the human body produce abnormalities to usual and regular state and behavior of the genetic information storage areas which further causes chromosome changes in body-related organs and germ cells (Balakrishnan and Das 2010).

The specialists might be viewed as a slight hazard assemble based on looking at the chromosomal dissimilarities, for nature in which they work is debased with volatile inorganic and organic compounds, segments of toner, formaldehyde, ozone, styrene and polycyclic aromatic hydrocarbons. Additionally, if the machine is harmed or inadequately introduced in congested environment, there are chances for a specialist to be in contact with UV radiation (Gadhia et al. 2005).

There are permissible allowances of radiation levels emitted by these machines. A comparative study on the printing machine with UV lamps and textile printing machines showed that digital printing machine having UV lamps releases huge amount of radiation. There is a decrease in the radiation levels during the non-operating mode (Kiurski et al. 2012a).

Environmental chambers are mainly used to identify and quantify the emissions of the office equipment's. Quartz or non-abrasive steel chambers operates at room temperature (21–23 °C) with humidity of (45–55% RH) are used to measure the emissions from printers or photocopy machines. These emissions are then compared with permissible amount of the radiation levels. Most of the machines produce only less radiation to the allowed level (Destaillats et al. 2008).

The continuous exposure to longer period of time will only cause some abnormalities in the individuals (Destaillats et al. 2008). The exact problems of pollutants on health of an individual are practically very hard to obtain, as different individual has different traits and resistances. (Kiurski et al. 2013).

UV radiations lead to various chronic and acute effects on eye, skin and immune system and it also affects skin erythema (Duthie et al. 1999). UV can also damage collagen fiber and further enhance aging of the skin. They also destroy vitamin C in the skin, which may cause further damage. High intensities of UV radiation are hazardous to the eyes and can cause welder's flash and may lead to cataracts formation (Riley et al. 1987). UV radiation may also be released through the glass plate, but at very low levels (Kotera et al. 1980). Modern equipment does not present a bright light hazard beyond short-term discomfort to the eyes, but it is recommended that the photocopy lid be kept down (Darr et al. 1992). Also due to increase in temperature of the machine, the operator is induced to stress and muscle fatigue (Zamanian and Hardiman 2005). It can even reduce sperm quality in the males. So to avoid the health hazards from the machine due to radiation, the operator should use appropriate personal protective equipment which will reduce exposure from harmful radiation (Taylor et al. 1988).

As per the studies carried out by the author, location of the photocopying machines also plays important role to cause hazards to the environment around the machine. Mostly the location the machine in the office and institutions has been observed at the basement or at the ground floor of the building (Agarwal et al. 2014). Most of the time, the rooms of the photocopy focuses are described by clay tile floor, painted solid roof divider, aluminum confined glass entryways and furniture. Since there is no proper ventilation provided at the basement, the operator is more expose to the radiation from the machine compared to the ground floor area (Singh et al. 2014).

One of the major reasons for radiation is also the utilization of the machine. In the single day, at the peak time, when machine is in continuous use, intensity of radiation increases which causes direct impact on the body of operator which absorbs the radiation to some extent (Sparrow et al. 1961). Also due to continuous use of machine, temperature of the machine increases which will in turn increase the temperature of the room and cause discomfort to the operator. Photocopy sheets must be encapsulated by radiation sensitive composite material to avoid the radiation emitted by the photocopy machine (Sanders et al. 1984).

Although photocopy/printing machines are important in our daily life, but they come with health issues which we neglect. Some very hazardous radiations like UV rays affect the human health who spend their most of the time around the operating machines. There we have to take some preparatory measures while operating Xerox/printing machine such as adequate ventilation, fresh air in room, sufficient dilution in room, use of gas mask when multiple machines are operating simultaneously, and repeated exposure should be prevented. Muscles feel stress and fatigue when they are continuously subjected to high temperature and heat. Following safety measures and proper precautions while operating will help to prevent hazard associated with printing and photocopying machines. Also the regulations provided by the authority should be followed to prevent serious health hazard.

The operator should maintain 1 m distance while working to prevent heat and temperature exposure from machine (Traister and Reehil 1976). Proper ventilation, air condition and separate room for photocopying measures can reduce hazard associated with photocopying/printing. Proper ventilation helps to increase heat dilution in the room and reduces the temperature even air-conditioning helps to maintain room temperature. It is always suggested to use devices like computer, printer and photocopy machines in cool room so as to prevent temperature hazard. Work rotation can help the operator to prevent temperature exposure.

Safety measures and discussion

Printing and photocopying industry have revolutionized the availability of documents and perceptible image quickly at extremely inexpensive and affordable cost. Sadly irresponsible, uncontrolled and extensive use, causing irreversible degradation to not only ecosystem by continuous release of O_3 and other VOCs but also the health of workers occupationally exposed to it.

Indoor air quality from photocopy centers of a city or for a large area in India has not been reported previously but reported for smaller area or for a center around the world by many researchers. Concentration of particulate matter has been observed twice or even more than the allowable limit during their work period. Photocopier discharges elevated amounts of particulate issue. Long haul introduction to outflows from scanners was not related to diminished lung work, but rather brought about high oxidative pressure and fundamental aggravation prompting high danger of cardiovascular illness.

However, a person operating in photocopying machine spends an average life of 7–9 h every day in his whole life up to a maximum age of 60 years (Gadhia et al. 2005) shows normal hematological characteristics. There are no standards in our country for the indoor air quality as the hazards of the machine operation are not known to anyone. The major problem that is encountered by the people operating the machine is genetic changes in their body slowly and immediate effects are the breathing problems and lung disorders due to the toners coming out from the machine such as lead barium and many particulate matters below 2.5 which is toxic and sometimes may prove fatal also (Ewers and Nowak 2006). From the various studies and research conducted by the author, it has been observed that indoor air pollution is cause of great concern as most of the time spent by a person is indoor and talking about the emission from photocopy machine it can be reduced to below permissible limits by taking some precautionary measures like having adequate ventilation for the flow of fresh air (Saritha et al. 2010), proper maintenance of machine, using good quality of toners in photocopy machines, by closing the lid during the photocopy operation.

Emission of VOC's is more compared to emission of compounds like styrene and benzene (Nel et al. 2006). Ozone particles emitted from printers combine with VOCs to form harmful secondary pollutants (Sarwar and Corsi 2007). Ultrafine aerosol particles are also emitted. Computers emit higher amount of VOCs compared to PM (Particulate matter). (Morawska et al. 2009). PM of different sizes viz $PM_{0.1}$ and $PM_{0.1–2.5}$ are released into the air. Emission of low level of ozone and VOCs forms secondary higher pollutants. (Cheng 2017). Dizziness, headache, nausea, irritation, inhalation etc., issues are caused by the emission of such elements in the air. PM has two different concentrations $PM_{0.1}$ and $PM_{0.1–2}$. Cleaning and maintaining these products also cause health issues (Pagel et al. 2016).

Safety measures for construction of building having photocopy operation

In modern time, photocopy/printing machines are the essential pieces of office equipment (Kagi et al. 2007a). Setting aside advantages and commercial utilization of the photocopiers, it has been observed that they are also sources of air pollution. In this process, pollutants like O_3, hydrocarbons, volatile organic compounds and dust are released causing indoor air quality problems (Lee et al. 2006). Among these gases, ozone is highly toxic gas and it is one of the most serious health risks which results in health issues such as headache, dryness in eyes, mucous irritation and tight and dry facial skin (Wolkoff et al. 1992).

From different examinations, it has been accounted for that there was hoisted DNA harm, among administrators in the printer focuses (Kleinsorge et al. 2011). The operators of the photocopier machines have a very high prevalence of breathing or respiratory problems such as excessive sputum production, blockage in the nasal and breathing troubles when it was compared to the control subjects. The reason behind this might be due to high exposure to particulate matter. This can further contribute to increase in respiratory symptoms and paranasal sinus diseases and also chronic nasal (Riechelmann et al. 2003).

The process of mixing or replacing contaminated indoor air with the fresh air coming from outside the building in order to decrease the level of its indoor contaminants is called ventilation. The types of ventilation methods used are mixed ventilation (MV), displacement ventilation (DV), personalized ventilation (PeV) and hybrid air distribution (HAD) (Cao et al. 2014). The main purpose of providing ventilation is to supply occupants with a suitable and good quality of inhaled air and also to dilute the airborne contamination present in it.

Nowadays, in many office settings, the ventilation rate procedure is preferable. It has been observed from studies that the minimum suitable exhaust rate for printing and copying rooms is 0.5 cfm/ft^2 (i.e., cubic feet per minute per square foot of the floor space) (Roth et al. 2003). And it should be replaced with the same volume of fresh or pure outside air or with adequately filtered, and re-circulated air delivered with requisite mixing (Karimipanah et al. 2008). There should be a minimum of 10% outside air to be mixed with the re-circulated air for office buildings. The emissions can be diluted to acceptable levels with the help of this method of allowing enough clean air to the space (Awbi 2017).

For some photocopy machines or printers or duplicators, there are ventilation kits available, basically, these are exhaust ventilation systems which removes the air directly from machine to an exterior location. An acceptable quality of air related with usual emissions from the machine is attained when a ventilation kit is installed (Wouters and Delmotte 2005). In ventilation, the outdoor air supply rate should be 2.5–10 L/s according to Standards and Guidelines (Olesen 2004). To measure ventilation, the parameter called RCH (Room air Changes per Hour) has been used earlier. In ventilation rate procedure, the ventilation rate that has been specified is expressed in terms of RCH, but it completely depends on the parameters—room ceiling, its height and the floor area (Seppänen and Fisk 2002). The World Health Organization (WHO) recommended that the continuous ozone exposure should be controlled below 0.05 ppm.

The idea that all air in a space can be changed is dependent on the completeness of new air displacing existing air, which is dependent on circulation and dispersion. Air changing requires that in-flowing air Q be equal to out-flowing air Q (Q in=Q out). Air change rates depend on the usage of the space but generally range between 2 (2 air changes per hour) and 20 for high use spaces like paint shops, for example (Turnpenny et al. 2001). In the 1950's, some high-rise building fire protection systems neglected air change resulting in catastrophic death rates from smoke under fire conditions. Venting systems are very concerned with indoor air quality. Venting systems work to change the air in a room or space for air quality purposes. It has been found from studies that the use of a ventilator decreases an average concentration of ozone near its source up to 50 µg/m^3, which is from an initial of 280 ± 63 to a final of 235 ± 52 µg/m (Weschler 2000).

Conclusion

Although photocopying/printing machine are important in our daily life, they come with health issues which we neglect. Precautionary measure has to be taken while operating printing/photocopying machine such as adequate ventilation, fresh air in room, sufficient dilution in room when multiple machines are operating simultaneously, repeated exposure should be prevented. These machines emit radiations such as infrared and ultraviolet radiations which in turn increases the temperature of room. Installation of photocopier in poorly ventilated confined place leads the emission of multiple hazardous gases like ozone, VOCs, SVOCs and heavy metals symptoms like fatigue, shortness of breath, headache, dizziness and nausea are the initial stage of poisoning of due to these hazards. Identification and quantification of concentrations of various specific particulate matters, ozone, SVOC and VOCs, emitted by major categories of photocopy machine plays a critical role in controlling air pollution. Characterizing the effects of emission on different age-group at different time is a major area of concern which has not been explored till date. Advancement of the importance of operational components which can be exploited to lessen outflow of contamination frame photocopy machine is required at some point or another for economic improvement. Investigation of the understood linkage between contamination emanations and vitality utilization for equivalent errand performed by machines is likewise not extremely regular which we have to center.

Hence to conclude on the topic, ample evidence is provided to the reader owing to the fact that there are adverse health implications and it is high time to take necessary measures. Much of the impact of photocopier machines can be put to limit by introducing common house plants in workplaces, adopting clean photocopy innovations, proper engineering measures, and a well-designed awareness campaign to enhance the environmental safety and design of these enclosed spaces. Thus, ensuring increased work productivity with utmost importance on individual health, ergonomics and ensuring the safe working of photocopier machines, regulating a routine check and use of dust/chemical collectors which prevent the outflow of various particles accounting as a hazard to human health. As a customary rule, high usage of a photocopier may be duplicating machinery; there should be a separate ventilation room with mechanical exhaust.

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