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RESEARCH ARTICLE

OCCUPATIONAL HEALTH EFFECTS DUE TO THE EXPOSURE OF SOLVENTS: A CRITICAL REVIEW

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ABSTRACT

In the pharmaceutical, chemical and other industries, the use of various different kind solvents is a common practice, which are mostly used in enhancing the reaction, purification of the synthesis of the products and also it is used in the cleaning of the various equipment's such as reactors and centrifuges. As exposure to the solvents are hazardous and critical in nature, so it is necessary to take proper safety precautions, while handling of the solvent. In case the solvents and chemicals are not handled properly with the safety norms, it will have a negative effect on the health of the occupants in the working environment, thus resulting in the various disabilities or nonfunctioning of the various parts in the human body. Higher exposure for the longer duration leads to the fatality. Throughout the globe the exposure limiting concentration is measured in the various forms, which has been discussed in this paper. Recent WHO report for the exposure of the chemical since 2016 to 2019 has been presented. The review helps the occupants in industrial environment to know the various exposures of different solvents, its effects on health and the limitation of the standards, which have been followed globally. The various threshold limit specified by the various international bodies have been presented.

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INTRODUCTION

The volatile solvents, which are used in the production activities by the chemical, pharmaceutical industries and other industries which contribute to the exposure of the vapors in the working environment due to the handling, storage, transferring, transportation, and utilization during the various activities in the production process[1]. When the mixtures of the concentration of the vaporous of the solvents, which are present in the working environment will lead to the uneasy and uncomfortable working conditions. Thus, resulting in the deteriorating of the health of the individuals working in the organization[2], which has been resulted in the economic loss to the company. In united states around 1 billion dollars have been spent due to illness in the working environment[3, 4]. The molecular mechanism, which have been derived from the solvents have higher toxic levels, their exposure will have deadly effect by effecting the various parts of the body[5, 6, 7]. Many of the countries have strict rules and regulations, which have been recommended to follow while handling the solvents and chemicals. These regulatory procedures help us in preventing the occupational exposure hazards[8]. The guidelines recommended for the risk associated to the exposure with the chemicals and solvents have been expressed by many of the international regulatory body in the form of PEL, TWA, STEL, IDLH and REL by OSHAS, NIOSH and ACGIH, which are explained in the Table. 1. In India, the permissible exposure limit and short-term exposure limit with respect to the various chemicals and solvents have been listed in the schedule 2, section 41 F of factory act 1948. The state governments, which has openly published in the Director General, Factory Advice and Labor Institute of Mumbai DGFASLI web site, so that public at large can view it and enhance the knowledge of the exposures of the chemicals and their solvents. The solvent has the ability to dissolve in the lipids, fats, oil, which is known as lipophilic compounds. These compounds are to be converted in to water soluble compounds through the osmotic conversion, which helps to urinate through the kidney[9]. Figure. 1 shows the exposure in the form of absorption and the inhalation of vapours entering in to the various organs of the body. The distribution mechanism and the elimination phase, which comes out in the form of expired air, urine and feces. Due to absorption, the occupational skin diseases have been increased in the recent time, as estimated of around 82,000 chemicals, which are used by the chemical, pharmaceutical and other industries. Further around 700 new chemicals have been introduced, which have direct impact on the skin[10]. Northwood et al.[11] reported that an estimated of 1.9 % among the 10,000 employees have been exposed due occupational exposure on the skin in the United

States of America in the past. The center for disease control and prevention (CDC), which publishes NIOSH guide line, in that the skin exposure notation is in the form of SK, which describes about the skin absorption, its irritation and toxicity effects of chemicals on the skin[12]. 34 % of skin occupational diseases have been reported across the Europe in the past[13]. The skin disease has been classified as skin infection, skin cancer, skin allergy, pigment disorders and its miscellaneous types [14]. The Berlin Forum on Chemicals and sustainability: Ambitions and Actions, which was held recently on 7th July 2021, in that session Mr. Tedros Adhanom Ghebreyesus, (WHO) Director- General has revealed that there should be a strategic drawing of global road map among the global community for safe handling of the chemicals through the participants of 5th International conference on Chemicals management. He has informed that every day between 4,270 to 5,400 people died due to the occupational exposure of chemicals. The young adults and the children are affected due to the hazardous chemicals and unilateral poisoning, as published in the recent World health organisation WHO report. The European union wants stronger contribution for handling of chemicals, which are mainly focussed on toxic free future as said by Virginijus Sinkevičius European Commissioner for Environment, Oceans and Fisheries in the Berlin forum. In a recent data, which has been released by WHO, the deaths due to the occupation exposure of the chemicals since 2016 to 2019 has been revealed Figure. 2, which is a shocking news. It showed that the acute poisoning deaths has been decreased but the deaths with respect to the occupational poisoning due to the exposure of the chemicals has been increased by more than 49 % since 2016 and 2019. There is an alarming increase of deaths due to the exposure of lead, which has increased to more than 67 %. Long term effects of the occupational exposure leading to deaths have been increased by more than 8 % and the deaths due to the exposure to the fumes, gases, and the dust particles has increased by more than 24 % since 2016 to 2019 Figure. 2.

Similarly, in the recent WHO reported data shows that the disability adjustable life years, rate of deaths due to acute poisoning has been decreased to more than 23.7 %, while there was an increase in deaths by more than 52 % due to the occupational poisoning for the daily disability adjustable life years, since 2016 to 2019 Figure. 3, which is an alarming rate of increase. Similarly, daily disability adjustable life years deaths due to the exposure of the lead pollution, long term exposure of chemicals and exposure of the occupational particulates like fumes, gas and dust has increased by more than 56, 19 and 26 % (Figure 3). Keeping the above figures, it is very much necessary to follow the new recommendation of occupational exposure limit latest 2020-2021 recommendation laid by the Japan society for occupational health JSOH, which are most stringent standards compared to the other standards of different countries in the world has been discussed in this paper. The solvents are categorized in to hydrocarbons, alcohols, ethers and the chlorinated solvents, their exposure limits of the PEL of (OSHAS) and IDLH of NIOSH has been presented in the Table. 2. The critical solvents, which are used in the various different industries, the exposure of these solvent leading to the deteriorating of the health of the occupants has been presented in this paper along with the standard exposure limits of OSHAS, NIOSH and JSOH.

Toluene: Exposure to the organic chemicals, which results in dysfunction of the cerebellar, damage to the optics, other cranial neuropathies and parkinsonism [15, 16]. The hydrocarbon in the form of toluene has been used in the different kind of industries such as coating, insecticides, paints, Specialty chemicals, adhesives, pharmaceuticals and chemical industries. The fatality of the toluene syndrome has been first reported in the year of 1979[17], it has resulted in the growth retardation, dysmorphia, giddiness, similar to that of the alcohol consumption[18, 19]. Toluene is highly flammable, irritant and carcinogenic in nature. In united states around 2,80,000 workers have been exposed to the deadly solvents like toluene[20], whose PEL of OSHAS and IDLH (NIOSH) are 200 and 500 ppm. The recent OEL standard recommended by JSOH in the year of 2020-21 were 50 ppm, which is four time less compared to the PEL of OSHAS recommended standard. It is estimated that more than 3 million tons of toluene have been produced in the united states[21], it is also used in the manufacturing of the house hold products. They are potentially exposed due to the inhalation of the vapours, although the exposure may enter the pores of the skin[22]. Long term exposure leads to drowsiness, headache, nausea, its higher concentration leads to cardiac arrhythmia[23 - 25]. The elevated anion gap metabolic toxicity is caused due to the exposure of toluene[26]. Due to the exposure of the toluene solvent, the bones of the skull and the face, which will result in the flat nasal bridge, size of the ears will become small, Bartarlla-Scott syndrome will occur, the midline labial fissure will be poisoned, pattering of the scalp hair will lead to the abnormality and similarly it happens in the anterior fontanelle[27-30]. Various authors who have studied the exposure of the toluene in several countries have made the collection of the clinical trial, neuro imaging and neuropathological information on the neurotoxic effects of toluene [15, 31-33]. The MRI scan images show specific effected portion, which is white in colour and a consistent profile of neurological and neurobehavioral, which leads to impairment [33, 34].

Benzene: Benzene is a colourless or light-yellow liquid chemical at room temperature. Exposure to benzene causes cancer[35-37]. It is reported that low levels of benzene from gasoline fumes, which comes in the form of a secondary smoke will pollute the atmosphere. People who use tobacco, its smoke contains benzene, which is a source of exposure of benzene, which causes cancer[36]. Exposure to benzene increases the risk of developing leukemia and other blood related disorders[38]. Although its exposure is mainly caused though inhalation[39, 40]. PEL OSHAS is 1 ppm, whereas the 2020 - 2021 OEL recommended by JSOH for nitro benzene is 0.1 ppm. The minimum benzene concentration has a deadly effect on the occupational work environment. The 6 mg/m^3 8 h time-weighted average is the Chinese occupational exposure limit, which are higher when they are compared to the OSHAS recommended PEL standards[41], similarly the scientific expert group to European Union countries have recommended less than 3.25 mg/m^3 for the exposure of the benzene concentration in the occupational environment[41], which is also more than the OSHAS recommended PEL standards. Benzene is highly toxic, flammable, carcinogenic and irritant. While testing the toxicity experiments using rat, it was found that the potential toxicity of the benzene is present in the ovary[42]. Considering the severe toxicity of the benzene, global community has put regulation in to place for the safe use of the benzene[43]. Genetic damage can be caused due to the exposure of the lower

concentration of the benzene[44]. The meta-analysis showed the relationship between the genetic damage and exposure of benzene [45]. Although globally many studies have been reported about the different type of the genetic damage [46-48], which has resulted in elevated exchange of Chromosome aberrations (CA), Micronucleus (MN) and Sister chromatid exchange SCE among the employees and contractors who are working in an occupational environment, its findings were reported in the Epidemiological studies [49,50]. Yanhua Zhou et al.[51] reported that meta-analysis resulted in the occupational exposure of benzene, which has an significant increase in CA, MN and (SCE) compared to control group. The IDLH of NIOSH is 500 ppm.

n-Hexane: Exposure to n-Hexane causes severe neurological problems. Occupational exposure of the n-Hexane will lead to muscle wasting and atrophy[52], which is mainly caused due to the inhalation. The PEL of OSHAS and IDLH of NIOSH of the n-Hexane are 500 and 5000 ppm. The occupational exposure limit of *n*-hexane as recommended by European Commission is 20 ppm[53], the JSOH recommended standard for 2020-21 OEL standard are 40 ppm, which is twelve times less compared to the PEL of OSHAS recommended standards although the European commission standards are less compared to the OSHAS and JSOH recommended standards. Exposure to the n-hexane will lead to the irritation and burning sensation[54]. Loss of weight have been observed during the intermediate exposure of the n- Hexane. Karakaya et al[55] reported that exposure to n-Hexane will lead to immunological effects in human, resulting in decrease in the immunology, some studies reported that immunological effects in the blood were in the normal range, although further study is needed to conform it[56]. It is also reported that exposure to n-Hexane will cause neuro toxicity effect[57, 58]. The electrophysiological studies were conducted due to the exposure of n-hexane, in this regard many authors have observed that there will be decrease in the velocity of the nerve condition, reduction in potentiality of the muscle action and also resulting in the focal conduction block[59 – 62]. Exposure of n-Hexane in work environment is mainly caused by the poor ventilation[63]. The toxicity studies have been conducted on the peripheral nerve of the rat by using n-Hexane, n-Pentane and n-Heptane, in that study it was concluded that n-Hexane was more neuro toxic to the peripheral nerve of the rat compared to that of the usage of n- Pentane and n-Heptane [64, 65].

Methyl Ethyl Ketone (MEK): It is highly toxic and flammable in nature. Thompson[66] have studied the exposures of the solvent and reported that it will have impact on the humans. MEK causes depression to the central nervous system and it is mild irritants to the eyes, skin, and mucous membranes. Miyasaka and colleagues[67] have reported concentration levels of MEK was 34 ppm, when they are exposed to air, although it was below the recommended standard of 200 PPM PEL of OSHAS, the recommended standards were similar to that of the OEL of JSOH 2020-21. In the other case Kawai, Zhang and Takeuch[68] have reported that MEK concentration was 6.7 mg/l in the urine for the 8 hours exposure of 200 ppm, which is equivalent to the OSHAS PEL recommended standards. The MEK concentration in the urine were higher when compared to the JSOH 2020-2021 OEL recommended, the recommended concentration limit of MEK in urine is 1.7 mg/l. Simon Thomas[69] has reported that the concentration of MEK of 100 ppm will have irritation of throat and nose, further increase in concentration of 200 ppm will result in eye irritation, 300 ppm will lead to headache and MEK concentration between 300 to 600 ppm will result in weakness and damages the peripheral nerves. The highest concentration of 3000 ppm, which will result in death, this will lead to the immediate danger to the life and health IDLH of NIOSH.

Xylene: It is used in paint, leather and printing and petroleum industries. Its concentration smells in air at 0.08 to 3.7 ppm and also concentration of 0.53 to 1.8 ppm increases the taste in the water[70]. Exposure to xylene, which leads to acute and chronic health effects takes less than 14 days and greater than 365 days[71, 72]. Exposure to xylene more than 150 ppm will lead to dizziness, weakness, vomiting and irritability and also exposure of 200 ppm for three to five minutes will lead to Throat infection[70, 73]. The exposure concentration of xylene of 150 ppm is more than recommended standard of PEL 100 ppm of OSHAS. The JSOH 2020-2021 stringent standards for OEL were 50 ppm, which is 50 % less compared to the recommended OSHAS PEL standard. The occupational exposure will directly interact with the proteins in the membranes[74]. It is recommended to use the xylene under localized ventilation under the provision of the hood[75]. There is no evidence that it will impact the concentration of the blood and causes cancer[70]. It was reported that the xylene concentration can easily penetrate through the damaged skin in the form of absorption[76]. In case the xylene penetrates through the clothes it will lead to the burning of the skin[70], Occupational exposure more than 100 ppm leads to the lung congestion[77]. The IDLH of NIOSH is 1000 ppm. Although is reported that xylene concentration exposure leaves the body in 18 hours [78].

Ethylbenzene: It colourless, flammable liquid that smells like gasoline. It is used in the manufacture of styrene gas, plastic and rubber. It was reported that acute short-term exposure to ethylbenzene in humans results in respiratory effects, such as irritation of the throat and chest constriction, eye irritation, and leads to neurological effects, which results in dizziness. The recommended OSHAS PEL and NIOSH IDLH were 100 and 2000 ppm. The JSOH recommended the OEL-M concentration was 100 ppm, which has been revised 50 ppm in the year 2001, it has been categorized under group 2B for its carcinogenicity. Presently in the recent recommendation of JSOH 2020-21, the recommended OEL concentration is 20 ppm, which is five times less compared to the PEL of the OSHAS recommended standards. Tetsuo Nomiyama[79] reported that 30 ppm of exposure of the ethylbenzene will lead to the hearing loss, which is more than three times recommended standards of PEL of OSHAS and less than the recommended OEL standards of JOSH.

BTEX: It is combined exposure effect of Benzene, Toluene, Ethyl benzene and Xylene BTEX in the occupational environment. BTEX exposure in the air, which leads to the poor air quality. it effects the workers working in the occupational environment and also the public health [80, 81]. Hamid et al. [82] reported in an occupational environment, traces of concentration toluene were high followed by Xylene, then ethyl benzene and least is benzene. BTEX concentration exposure varying more than 16 to 33 ppm will lead to respiratory tract irritation in the living beings[83].

Figure 1. Recognized body/organization setting the standards for the exposure of the vapors, dust, fumes, smoke and noise

Sr. No	Short Form	Abbreviation	Recommended body / Organisation	Units Expressed	Exposure Time
1	PEL-TWA	Permissible Exposure Limit - Time weight Average	OSHA	PPM	Exposure of 8 hours per day in continuous basis
2	STEL	Short TERM Exposure Limit	OSHA	PPM	15 minutes Exposure in working environment
3	TLV	Threshold limit value	ACGIH	PPM/(mg/m3)	PPM for gases & mg/m^3 for particulates such as vapour/ dust / smoke /mist.
4	TLV-TWA	Threshold limit value – Time weight Average	OSHA	PPM	8 Hours of continuous exposure / day or 48 working hours of exposure per week
5	IDLH	Immediately dangerous to life / Health	NIOSH	PPM/ (/mg/m^3)	Standards available for various chemicals and solvents
6	TWAEV	Time weight Average Exposure value	OSHA	mg/m^3	Average Vapour/ gas exposure 8 hrs/day or average 40 hours of exposure per week
7	OEL	Occupational Exposure limit	Set by the individual nation	mg/m^3	Maximum concentration of the exposure to fumes, gases and chemicals in a given period of time
8	REL	Recommended Exposure limit	NIOSH	Db	Recommended - Noise exposure is less than85 dba for 8 hours TWA
9	BAC	Blood Alcohol Content	The American Medical Association	mg/day	Recommended - BAC should be between 10 to 80 mg/day
10	TWAS	Time weight average spread for exposure	OSHA uses the guide line to recommend the PEL	PPM	Exposure of hazardous substance like chemical, vapour, fumes and mist in an occupational environment for 8 hr of time
11	TWAC	Time-weight average concentration	ACGIH	PPM	The average exposure of 8 hours per day or 40 hours per week, which does have any adverse effect
12	MAC-TWA	Maximum available concentration eight hours, time weight average.	OSHA	PPM	The actual concentration of exposure of 8 hours/day should not exceed the recommended PEL
13	OEL-JSOH	Occupational Exposure limit	JSOH	Ppm	The exposure concentration standards for for 8 hours per day, 40 hours per week under a moderate work load

Note – OSHA – Occupational safety health administration, ACGIH – American council of governmental industrial hygienists, NIOSH – National institute of occupational safety and health and JSOH – Japan society of occupation health

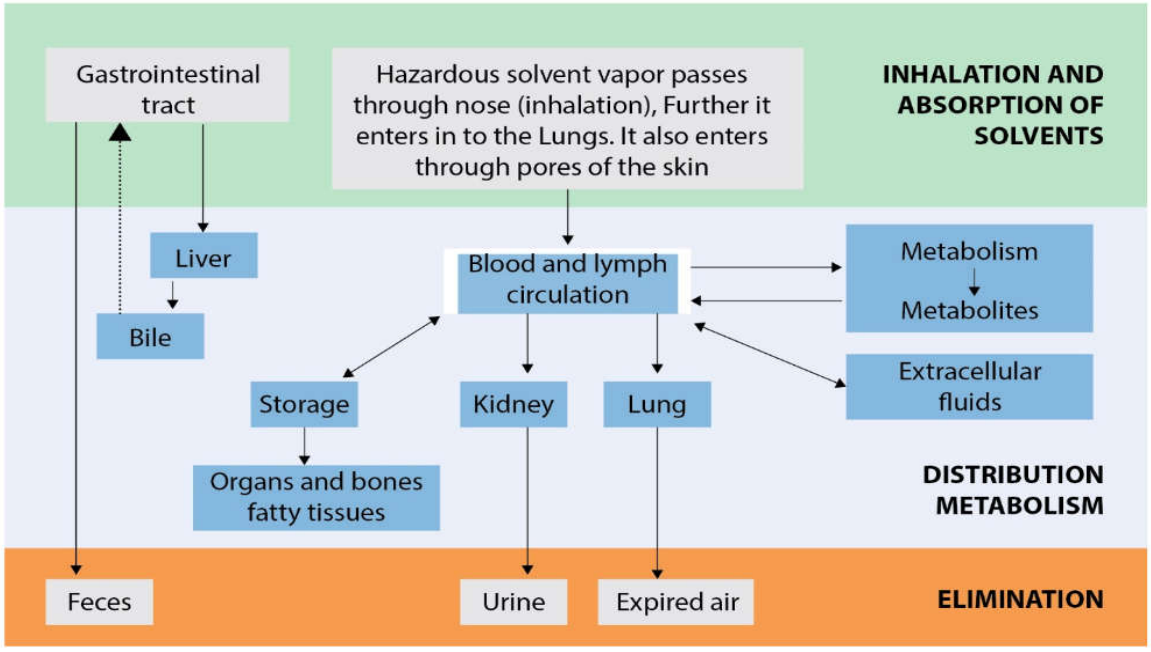

Fig. 1. The solvent exposure, distribution and elimination mechanism in the human body

The long-term exposure of the BTEX concentration will affect the liver, kidney, respiratory tract, central nervous system and the reproductive system[84]. Several adverse effects have been reported in the countries like USA, China and India[85 – 89]. Individual standards of exposure concentration exist for the Benzene, Toluene, Ethyl benzene and Xylene are available but combination standard exposure limits of BTEX values are not available, as further depth studies needed to set the exposure standards.

n-Butanol – It is a mild toxic in nature. It is flammable, cacogenic and irritant in nature. Exposure to n-Butanol leads to gastrointestinal symptoms such as abdominal cramps, vomiting, nausea and diarrhoea.

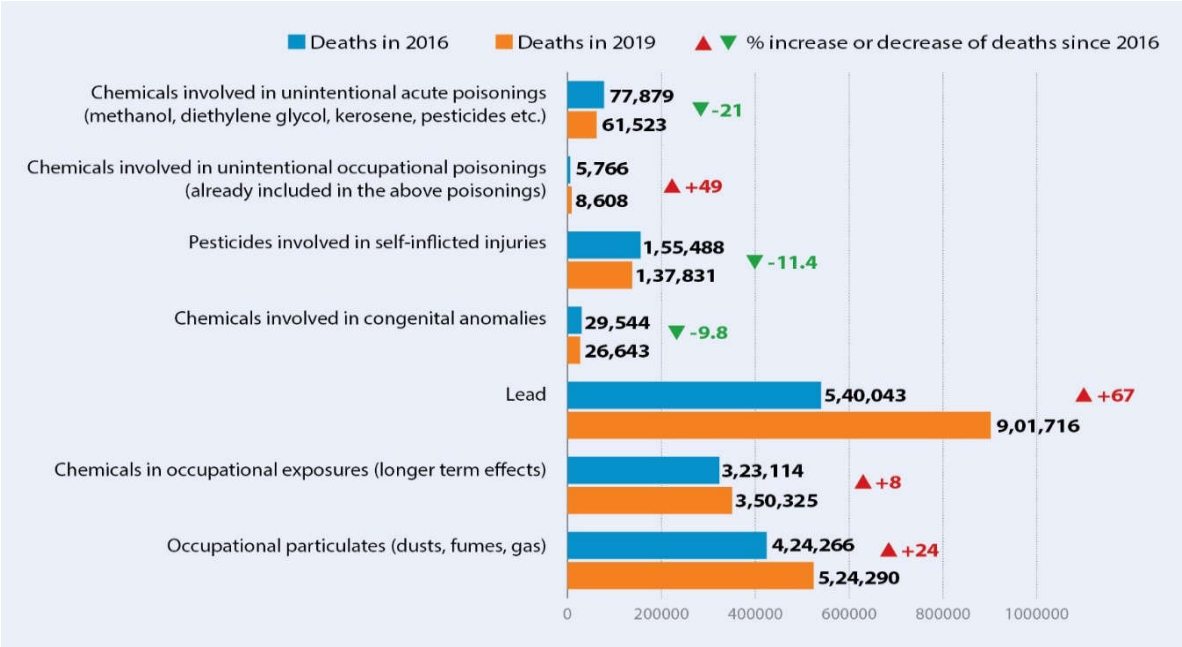

Figure 2. Recent WHO Report 2021, Percentage of increase or decrease of death since 2016 to 2019 (Published Source data – Mr. Kiran Pandey, Down to Earth, 8th July 2021)

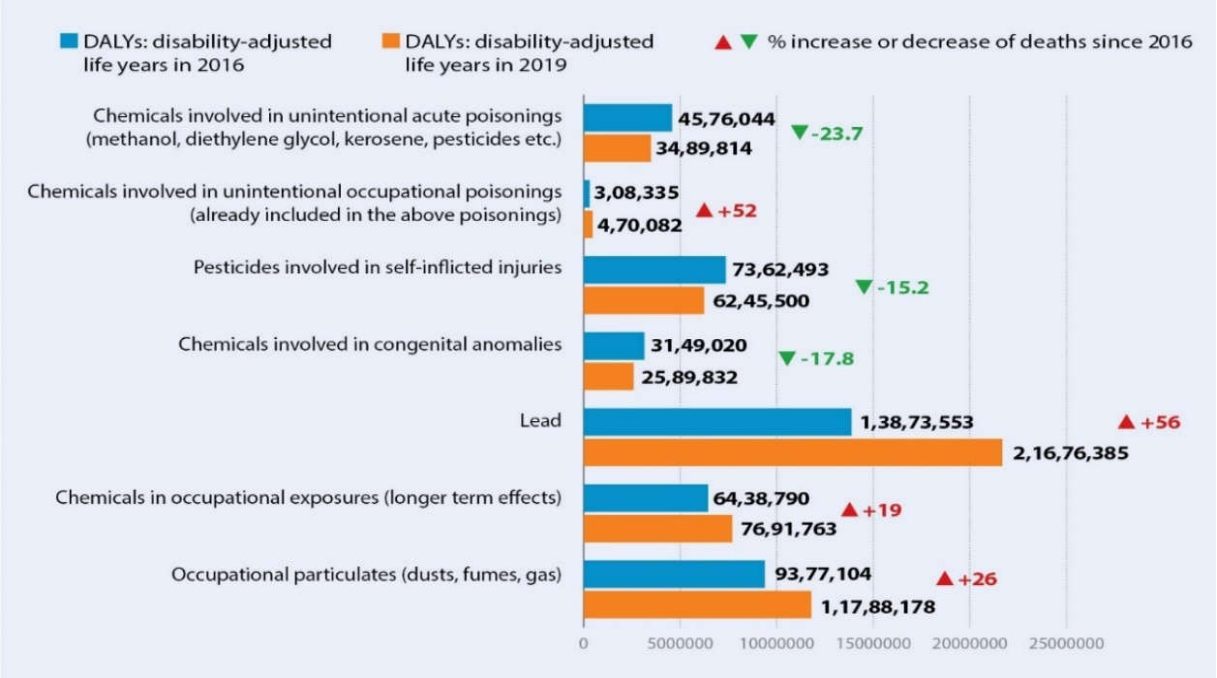

Fig. 3. Recent WHO Report 2021, percentage of deaths for the occupational disability adjustable life years, since 2016 to 2019 (Published Source data – Mr. Kiran Pandey, Down to Earth, 8th July 2021)

It will impact the neurological system of the body, which leads to headache, dizziness and giddiness. Can cause hypotension and cardiac dysrhythmias, and if aspirated, a haemorrhagic pneumonitis. With severe respiratory exposures, pulmonary edema can occur. Severe ingestions can cause gastrointestinal hemorrhage and liver injury[90]. The OSHAS and NIOSH standard for the PEL and IDLH are 100 and 8000 ppm. The new JSOH recommended standard for 2020-21 OEL standard for n-Butanol are 50 ppm, the standards were 50 % less compared to the OSHAS PEL standards.

Methanol: The route of exposure through ingestion will cause deadly consequences, which will lead to severe metabolic disturbances, blindness, permanent neurologic dysfunction and death. Methanol will become harmful when it converts it into formic acid. The formic acid damages optic nerve and retina, which is caused due to the disturbance mitochondrial electron transport[91]. Three phases, where the methanol toxicity can be said [92. 93], first is in the early stage where it leads to inebriation, weakness, dizziness, mild euphoria and nausea, next is the second phase results in disturbances of the vision, blurred vision, bilateral mydriasis and occasional blindness. In the third phase the retinal necrosis is affected due to the neuronal injury[94]. It is flammable and carcinogenic in nature. PEL of OSHAS and IDLH of NIOSH of methanol are 200 and 6000 ppm. The new OEL recommended by JSOH 2020-21 were similar to that of the OSHAS PEL standard.

Ethanol: It will lead to intoxication. Its exposure will lead to hypotension Low blood pressure, hypoglycemia Low blood sugar, Nausea, vomiting and excess urination. It is flammable, irritant and cacogenic in nature. Ethanol and alcohol are same, ethanol is another type of alcohol. Consuming alcohol and working in an occupational environment will lead to accident and further it will lead to disaster, in case a person handles a critical activity. Exposure to ethanol leads to adverse effect, which includes social inhibition[95, 96], it effects the functioning of the limbs and other parts of the body[97 - 99]. The OSHAS PEL and IDLH of NIOSH are 1000 and 15000 ppm.

Ethyl Acetate: It is commonly used in glue, cigarettes, paint, nail polish and perfume. It is by-product of acetic acid. It is highly flammable in nature. It's inhalation or ingestion is highly toxic in nature. These chemicals can be seriously damaging to internal organs in the case of repeated or prolonged exposure. The OSHAS PEL and NIOSH IDLH standards are 400 and 10,000 ppm, the JSOH 2020-21 recommended OEL is 200 ppm, which is 50 % less of the recommended PEL of OSHAS standards. Any exposure of the concentration of the ethyl acetate will lead to the irritation to the throat, eyes, nose, giddiness and unconsciousness[100]. Toxicological studies showed that the exposure to the ethyl acetate LD50 5620 mg/kg results in the lower toxicity among the rats[101]. Other solvents along with the ethyl acetate have been used for the column chromatography in the chemical laboratory.

Chloroform: It is used in many industries such as pharmaceutical, chemical, pulp and paper mill, refrigeration purpose, hazardous waste site and certain landfills. Occupation exposure to the chloroform leads to damage of skin, eyes, liver, kidney and nervous system. Exposure to chloroform will cause irritation and also it leads to cancer. It is harmful to the environment. The chloroform compounds, which are let in to the environment through the bleaching process in the paper industry[102]. The geno-toxicity critical examination studies, which revealed that the exposure of chloroform will lead to cancer through a nongenotoxic-cytotoxic mode of action[103-108]. The recommended PEL of OSHAS and IDLH of NIOSH were 50 and 1000 ppm. The new JSOH 2020-21 OEL recommended concertation is 3 ppm, which is more than 15 times less compared to the OSHAS PEL recommended concentration.

Dimethyl formamide: DMF – DMF is a commonly used solvent, which is used in the synthetic fibre, inorganic chemicals and in the pharmaceutical industries. Exposure to the DMF in the occupational environment, which effects the working environment and the health of the occupants. China uses highest quantity of DMF, approximately it produces 45 % global DMF per year[109]. Luo et al.[110] reported that the 27 % workers have abnormal functioning of the liver, where the occupants have been exposed to DMF around 10 PPM, which is equivalent to the OSHAS PEL recommended concentration and JSOH 2020-21 OEL standards. DMF exposure will damage the digestive system and also damages the kidney function[111]. NIOSH IDLH for DMF is 3500 ppm

SHORT DISCUSSION ON THE EXPOSURE OF THE SOLVENTS

We have covered the key and major critical solvents and their exposure, which are used in the different sectors. Although keeping the modern world of innovation in the scientific community, it is leading to the many discovery of the new chemicals and solvents. The exposure concentration in the occupational environment playing a key role to determine the limiting factor of exposure in the working environment. Globally they have conducted many toxic studies with respect to the exposure of the solvents and chemicals [7, 112 – 121]. Various toxicity of exposure of solvents in the occupational environment have been discussed in this paper. by considering the global death rate, which has increased by 24 % since 2016 to 2019 in the recent WHO report Fig .2, this is an alarming rise in the deaths %. It is recommended to use the organic solvents in the closed loop system or under fume hood to avoid the vapour concentration[122]. Proper Personal protective equipment PPE and trained people are necessary for handling the solvents. Now a days the concept of green chemistry has been introduced in order to avoid the toxicity of the solvents in this modern world[123 – 128], we are more focused on the critical issues with respect to the occupational exposure and standards, which are used globally has been discussed in this paper, so we have limited our discussion with respect to the green chemistry.

Conclusion

In the modern scientific world it is very much unavoidable usage of the solvents in the different sectors. The workers should know the exposure limits and the safety precautionary measures for handling of the solvents. In this paper we have covered the health effects of the critical solvent's exposure in the occupational environment. Globally there are many standards for knowing the exposure limits of the chemicals and solvents in the occupational environment. The latest standards, the recommendation of the occupational exposure limits 2020-2021 by the Japan society of occupational health JSOH are one of the most stringent standards compared to the other standards in the world has been well known through this paper. Finally, we pledge to work safe by adhering to the various occupational exposure limits in the working environment.

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