
TOXICITY ASSESSMENT OF HAZARDOUS INDUSTRIAL SOLVENTS

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ABSTRACT

As concern about environment and health hazard of toxic substances has grown, there is need to generate awareness among people about risks of chemical present in workplace or in the community. Everyone has the right to know about toxic hazards. Once they can do, they can accept risk or demand changes in toxic use. An attempt has been made to study most commercial solvent and their toxicity on human health. Toxicity of chemical agent can be influenced by its composition. Some of the chemicals have pharmacological action or some narcotic effects. Our society is hooked on chemical of its own making. During past few decades, approximately 10,000 new chemicals have been manufactured and introduced into the market. Virtually, every aspect of life is influenced by these toxic chemical from production to recreation. Those can enter inadvertently in our food, water or air. Toxicity of solvent can be assessed by studying its acute or chronic exposure to human or natural environment. Chronic exposure induce major part, or the entire life cycle of organism. Most of studies show that low dose exposure of industrial solvents exerts a depressant action on the nervous system. Exposure of large dose of solvents can cause certain death. Special attention has given to study commonly encountered laboratory solvents.

Keywords: Toxicity; solvents; health; exposure; prevention

INTRODUCTION

Chemical compound can be classified in two major groups called as organic compound and inorganic compound. Organic compound often described as compounds of carbon with hydrogen or other functional groups such as oxygen, nitrogen, sulphur etc. The inorganic compounds are described as compound other than carbon such as hydrochloric acid, sulphuric acid. Solvents are a group of chemical, widely used in industry and at home. The solvent means a liquid used to dissolve other substances. The term Solvent generally refers to organic solvent. But, it can be liquid or gases. Solvent can be classified as oxygenated, hydrocarbon or halogenated solvent. Oxygenated solvent are those which contain oxygen and are synthesized from other chemical such as alcohol, ether, ester, ketone etc. Hydrocarbon solvents are those which contain carbon, hydrogen and derived from petroleum such as benzene, gasoline, kerosene, and methanol. Halogenated solvent are those which contain halogen such as Carbon tetrachloride, Chlorofluorocarbon, ethylene dichloride. Solvent has property to evaporate quickly and leave almost no residue when used to clean electronic and machine parts. Solvents are used to thin



Figure 1 depicts time to enter our blood

paints, glues, extract oils and glues. Most of solvents are hazardous, some are flammable, some explode easily and most of them are toxic. Halogenated solvents are highly toxic and most commonly halogenated solvents are chlorinated solvent are methylenechloride, trichloroethylene, trichloroethane, tetrachloroethylene. Many other toxic commercial solvents such as acetone, benzene, glycol, dioxane are used during manufacture of huge variety of everyday products. These toxic chemical we come in contact with everyday is staggering [1].

No doubt, they have numerous applications in industries such as paint, ink, pharmaceutical household cleaning etc. At home, we generally come across these hazardous solvent in the form of cleaning products, personal care product, nail polish remover, automobile engine or pharmaceutical products. A question always come in our mind how much time will it take for a chemical to enter in our blood stream. We can say here very few seconds as in Figure 1.

Another incident of toxicities is soil contamination with dioxin at Times Beach, Missouri (USA) killed many people. There is always a danger during shipping of chemical in truck or train or sea ships. Small dose exposure of toxic chemical to human may cause cancer or may affect on central nervous system. If it is long term exposure and become chronic, which affect present generation to coming generation. Our society is hooked on chemical of its own making. During past few decades, approximately 10,000 new chemicals have been manufactured and introduced into the market. Exposure of solvents to human affect to liver, skin, blood, central nervous system, kidneys. Virtually, every aspect of life is influenced by these toxic chemical from production to recreation. Those can enter inadvertently in our food, water or air. Solvents can also be absorbed into the body through the skin. When solvent spilled on skin it cause damage to skin cells and causing red, cracked or scaly skin. Short exposure of solvents cause lung and throat irritation, dizziness, confusion, irregular heartbeat. Long term exposure causing cancer, liver, kidney damage. Repeated exposure cause chronic bronchitis, permanent kidney and liver damage and permanent neurological problems. A great number of food preservatives and pesticides are deliberately introduced into our environment [2]. These substances believed to cause cancer or serious human health problem. Some solvents such as benzene, chlorinated solvents affect immune system of the body. It has been observed that solvent like glycol ether have birth defects and reproductive problems in animals.

COMMERCIAL SOLVENTS USED:

Acetone:

The structural formula of acetone is $\text{CH}_3\text{-CO-CH}_3$. It is clear colourless liquid with sweet fruity smell. It is soluble in water. Acetone is not skin irritant but a defating agent to the skin. It is familiar commercial solvents used by most people.

Uses:

It is widely used in commercial products, industrial process and chemical feedback. Acetone has been used as solvent in paints, varnishes, lacquers, paint removers and care products. It is used as a nail polish remover. Industrially, it is widely used as lubricating oil and used as a raw ingredient in the production of various other chemicals such as chloroform or in industries such as plastic, pesticides, adhesive and drugs. Acetone has been extensively used in industrial process such as in the manufacture of cellulose acetate yarn, polyurethane foam etc. Acetone has

been used in the manufacture of methylmethacrylate which led to formation of PMMA polymer and bisphenol led to formation of polymers such as epoxy resins and polyurethane. Acetone is important ingredient in many consumer products such as cosmetic and food products.

Potential Exposure:

Naturally, it is produced in the body as a by-product of metabolism. Low levels of acetone are found in our body. The fats and lipids stored in our body are rich source of acetone. During strenuous activity, it leads to breakdown of fats for providing energy and simultaneously releases acetone in bloodstream. Blood stream carries acetone to all body organs where acetone get break down to sugar for energy in carrying out normal process in the body. But, all acetone that enter our body do not get broken down. People get exposed to different sources such as primary anthropogenic, primary biogenic (vegetation), Biomass burning and industrial based reaction of hydrocarbon. If we are contact with alcohol, it means we are exposed to acetone because alcohol get oxidized in the body and convert into acetone. People who work in industries such as paints, polish, plastics, fibres, lacquers, airplane dope industries have more chances of acetone exposure. If a person frequently use polish remover, smoke or live near landfill sites, is more prone to acetone exposure than general populace.

Health hazard: The study reveals that concentration of acetone is predominantly present in air and water which cause serious threat to our environment. Mostly acetone is released in the environment by industrial activity. Once it enters into atmosphere, it degrades into lower hydrocarbon by photolysis [3] since its life time is just 22 days. People working in industries have irritation in noses, lungs, throat, and eyes. High concentration of acetone exposure cause headache, dizziness, unsteadiness, confusion, irritates eyes and mucous membrane. Long exposure of acetone cause fingernails to dry and split. Inhalation of high concentration can depress Central nervous system (CNS), cause dizziness, weakness and loss of consciousness. High concentration can cause liver toxicity. Excessive use at home causes childhood poisoning. Direct contact with skin cause drying of skin or damaging. Exposure of acetone cause cardiovascular, gastrointestinal. Derma, musculoskeletal neurological, reproductive, development effects and other systemic effects. Exposure of acetone Increase permeability of skin and enhancing absorption of dangerous chemicals [4] Other Common symptoms of acetone allergy are dermatitis.

Acetone is quite irritating to animals even acetone is quite harmful to eyes of animals if acetone come in contact with eyes. Exposure of acetone to higher concentration affects respiratory system, edema, and hemorrhage of lungs (especially in guinea pig)

Prevention:

- Use of well-ventilated sites at workplace where acetone is commonly used.
- Avoid prolonged inhalation of acetone vapours.
- Keep acetone and acetone containing product out of reach of children.

CARBON TETRACHLORIDE:

It is also named as Methane tetrachloride or tetra chloromethane or carbona. It is colorless, sweet smelling, syrupy liquid with high specific gravity 1.559 and boiling point 170.6⁰ F. Its vapour density is 5.33. In the air, if the concentration of CCL₄ exceeds 10 ppm, it produces unpleasant smell. Because of high chlorine content, it is highly toxic. It is found that toxic impurities such as phosgene, free hydrochloric acid, and organic sulphide are present in carbon tetrachloride.

Uses:

CCL₄ is widely used as solvent in rubber industry, cleaning agent in dry cleaning industry. It is used as Freon refrigerants R-11(CF₃Cl) and R-12(CCl₂F₂). But it was found that it is responsible for ozone depletion and its use was banned. Most of the CCL₄ is used to manufacture fluorocarbon propellant. It is used as a general purpose cleaner. It is used as solvent for oil, fats, varnishes, lacquers, waxes and resins. It is used in the manufacture of paints and plastics. It is used as anthelmintic for parasites in the medicine.

Potential Exposure:

The important source of exposure is production of CCL₄ in industries or use of pesticides, fumigants or use of paraffin wax production. Contamination of ground water with CCL₄ because of leaches into groundwater from industries. CCL₄ is non-biodegradable. It stays in the environment at least 50 years and not easily breaks do. The study shows that average person takes CCL₄ daily from air (62%), water (23%) and food (15%) industrial populated sites.

Health hazard:

Carbon Tetrachloride is toxic to liver and long exposure of CCL₄, it adversely affect lung and kidney. A study reveals that single dose can cause area of necrosis in the liver within minutes.

Overexposure of CCL_4 also leads to dizziness, vertigo abdominal pain, and vomiting, mental confusion are common symptoms. Continue contact of liquid CCL_4 cause skin rashes, skin blistering or skin irritation. Overexposure of CCL_4 leads to chronic and cause abnormalities in the eyes, damage the kidney, liver[5] Animal studies show that overexposure cause liver cancer in rats and mice. EPA (Environmental protection agency) studies also show that the mutagenicity among humans and probable it is carcinogenic. CCL_4 is also responsible to damage environment by depleting stratosphere ozone

DIOXANE:

Dioxin is an important commercial solvent. It is also named as 1, 4-dioxane or p-dioxin or diethylene dioxide. It is basically cyclic ether with sweet smelling liquid. It is prepared by dehydration of two molecules of ethylene glycol in the presence of concentrated sulphuric acid. Its structure can be written as



USES

Dioxane is used as stabilizer in the manufacture of paints and used for storage and transport of chemical in aluminium container. It is used to remove water from tissue sample in science laboratory. It is used as window cleaner. It is widely used inks and adhesives.

Potential Exposure:

Mostly exposed to people in those places where it is commercially prepared. Exposure occurs as a result of accidents or spills during shipping [6]. No such direct contamination of dioxane in air is reported.

Health hazard:

Dioxane get easily absorbed through skin and intestinal tract. Overexposure of dioxane causes skin irritation to eyes and affecting respiratory system. Overexposure also leads to intoxication, narcosis, pulmonary edema and even death. Chronic exposure affecting central nervous system and damage liver kidney and reduce immunity. EPA studies show to be carcinogenic if overexposure of dioxane occurs. During shipping, if spills or accidents occur, it exposes a serious threat to groundwater contamination. Since, Dioxane is easily soluble in water and get easily penetrate into the soil and get mixed with ground water. It is also reported that it inhibit the naturally occurring biodegradation process. Dioxane has also been found in well water near

solid waste landfills and radioactive waste disposal sites. The main drawback is that it does not degrade when present in environment [7]

Dioxane is also found in commercial body care products such as shampoos, body washes, lotions, moisturizing cream, nourishing cream, bath soap etc [8]. Dioxane is chemically carcinogenic and act as kidney toxicant, neurotoxicant, respiratory toxicant.

ETHYLENE GLYCOL:

It is also named as 1, 2-ethanediol, ethylene alcohol, ethylene dehydrate. It has molecular formula $C_2H_6O_2$. It is clear, colourless syrupy liquid with a sweet taste.

Uses:

Glycol is used as a coolant in automobile such as cooling and heating system, hydraulic brake fluids. It is used in industries such as paints, inks, cosmetics, wood tobacco products and automobile break fluids. It is widely used as ingredient in condenser, paints and plastic industry. It is common solvent in polymer such as plasticizers, synthetic fibres (Terylene, Dacron). It is also used to de-ice airport runways and aircraft [9]

Potential Exposure:

Exposure of ethylene glycol is generally through workplace or consumer who uses products such as paints cleaners etc. Maximum exposure is due to use as a antifreeze in automobile and in break fluids. Exposure is also through cosmetic products which also contain glycol. There is chance of contamination of soil and ground water through spilling which damage our environment. High concentration of exposure of glycol is toxic in aquatic organism such as fish.

Health hazard:

Low exposure of ethylene glycol vapours cause respiratory infection. High exposure affect central nervous system depression, renal failure. Direct inhalation of vapours cause headache, throat irritation. Long term exposure affect animal species like damaging kidneys and liver toxicity in rats and mice. A study reveals that there is chance of tumors in mice. Special glycol ether such as ethylene glycol methyl ether and ethylene glycol ethyl ether affect reproductive system of animals. Ethylene glycol along with air enters into bloodstream of human cause toxic effect. Large dose of glycol exposure cause convulsion and coma. Overdose also cause irregularities of eye such as rapid eye movement, paralysis of eye muscles and blurred vision.

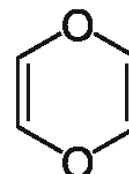
Reflexive movements get slowed down. Inhalation of vapours cause high blood pressure, rapid heartbeat, rapid breathing. It causes ozone pollution.

Since glycol is mainly used as antifreeze and any leaking from car should be avoided. Avoid those places where car or trucks are placed.

DIOXIN:

Dioxin is a heterogeneous six membered ring where two carbon atom are replaced by oxygen atom. Its structure is written as

Dioxin is present in a small quantity in our environment. It is quite difficult to detect by odour or appearance. But it is thought to be most toxic chemical. It is so poisonous that can cause illness to humans or animal even taken in small dose.



Potential Exposure:

Dioxin is a by-product of many industrial process such as chemical and pesticides industry, waste incineration which release chlorine when mixed with hydrocarbon. It is also unwanted product of combustion process of garbage or medical waste, cause release of dioxin in our environment. It is also released through forest fires or past burning of waste[10] It is by-product in the manufacture of herbicides such as 2,4,5-T. Industries such as bleached paper, card board food containers, paper are potential source of dioxin. Microwave dinners contain all possible sources of dioxin. Disposable diapers, toilet paper made from bleached paper all possible sources of dioxin. Wood preservative industries and metallurgical industries are rich source of dioxin.

Health hazard:

Exposure of dioxin causes cancer, birth defects. Dioxin not only cause cancerous effects but also noncancerous effect such affect reproductive system, immunological, endocrine effects and reduce neurodevelopment in infants[11] People working in herbicide factories if contact with dioxin result in skin disease. Since dioxin is fat soluble and present in meat, fish and diary products such as egg. When we consume these products in our food, these get bioaccumulate in our food chain and affect our health. People consuming non-veg food suffer more chances of dioxin exposure.

Prevention:

To minimize the exposure of dioxin, try to keep away from areas where herbicides are used. Also try to keep away from areas where organic waste and municipal waste are burned. Avoid garbage

incineration to see risk of harmful dioxin. Avoid use of chlorine based bleached paper and cardboard. Do not eat contaminated fish caught from waste water which is discharged from paper mill.

Benzene: It is also named as Benzol, carbinol, cyclohexatriene, or Phenyl hydride. Benzene is aromatic hydrocarbon with molecular formula C_6H_6 . It is clear, volatile, colorless, flammable and liquid with sweet smell. It is a natural constituent of crude oil. Benzene ring is basic building unit of naturally and synthetic occurring compound. In living organism, benzene ring is present in enzymes, vitamins, sugar which carry out various biochemical reactions in the body.

Uses

Benzene is used as intermediate for the production of many chemical and directly used in production of ethylbenzene, cumene, cyclohexane etc. Benzene is widely used in paints, oils, adhesives, pesticides, dyes, explosives, lubricants', drugs and many other products. It acts as a substitute for lead in gasoline which increases octane value. It is also natural constituent of jet fuel.

Potential Exposure:

Many indoor products such as glue, paints, wax, detergents are potential source of benzene vapour. Outdoor exposure from wood smoke, tobacco smoke, automobile service station are contain benzene vapours. Exposure of maximum population through Cigarette smoking is potential source of benzene. Although benzene is present in relatively small amount in cigarette but still release large amount of benzene. According to Report, a person who smoke 32 cigarettes per day, it means he inhaling 1.8 mg of benzene per day. Benzene in soft drinks is also great health concerns. If a person is drinking 350 ml of soft drink, it means one consumes 31 microgram of benzene vapour. Actually, benzene in soft drinks is formed by decarboxylation of benzoic acid [12] Industrial effluents discharge containing benzene is major source of surface water contamination. Leakage and leaching from where storage tanks are placed, contaminate ground water. Refining industries are rich source of benzene exposure to human. Inhalation of benzene vapours while filling the gas tank. Work place such as coal, and petroleum industries are exposed to benzene vapour.

Health hazard :

Benzene cause cancer and affect bone marrow. According to report of National institute of health (NIH) and IARC, benzene is human carcinogens. Long exposure of benzene cause leukemia. Benzene affect lungs, heart, kidney, brain and affect mutagenic changes. Long term exposure of benzene exposure affects male and female reproductive system. Chronic exposure cause abrupt change in bone marrow and cause chromosomal aberration and leukemia. Inhalation of benzene vapours through skin or eyes affect respiratory tract irritation or eye irritation. Inhalation of vapour in lungs cause pulmonary edema and hemorrhage [13]

Figure 2 shows how benzene get metabolized either through liver/lungs or bone marrow to form reactive metabolites and exert their toxic effects.. Large dose of exposure of vapours affect central nervous system and cause dizziness, nausea, coma, convulsion.

Prevention:

It is advisable that well ventilated place for workers and avoid direct exposure of pure benzene Wear protective clothing and goggles to avoid contact with skin and eyes. Reducing gasoline consumption to avoid contact with environment. Never discard old oil, paints, or gasoline, since they contain benzene. Try to contact with local agencies that control hazardous disposal

CONCLUSION:

Exposure of high toxic commercial solvents slows down the production of enzymes in the body. Their toxicity is enhanced when a chemical or its metabolite is enter into bloodstream and directly attack the target organ of body. Some chemical leave the body the same way they come in. But some time some chemicals are circulating in the bloodstream and follow a complex path before they get excreted. Kidney is most important organ for removing toxic substances from the body. Toxic substances that are metabolized by the liver exit the body via the feces. Some toxic substances may be excreted by sweating although amount of toxic substances is very small. Moreover, strong legislation concerning toxic substances is vital for the production of public

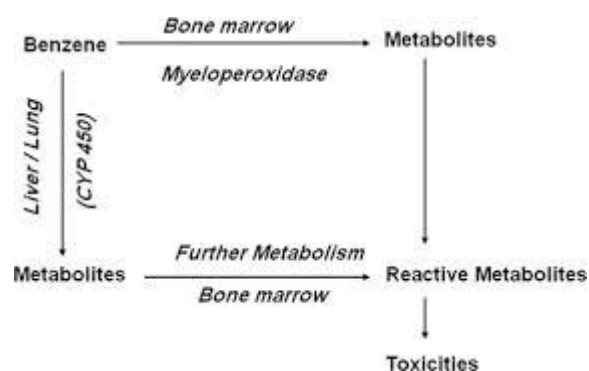


Figure 2 health effects of benzene

health and environment. It is the fundamental to the nation's well being. Comprehension policy and meaningful laws is dire need to check the toxicity in the environment. Besides this, Public awareness and better information about solvent risk at workplace, community. Appropriate steps to be taken to prevent potential problems by disclosing information and warning concerning chemical risks[14] There is dire need to right to know movement from local efforts by labour union to inform workers about hazards of toxic and reduce reliance on the toxic substances. Right to know programs require knowledge about hazardous toxic chemicals and establishing processes for emerging response planning and public information. Right to know laws are catalyzing business to review their use of toxics and improve corporate management of health risk.

More research is initiated on the subject, more suggested associations are likely to emerge. In the meantime, a balanced diet appears to some measure of protection from harmful effects of toxic.

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