IMPACT OF SOLVENTS LEADING TO ENVIRONMENTAL POLLUTION

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ABSTRACT

There has been increasing global concern over the public health impacts attributed to environmental pollution, in particular, the global burden of disease. The World Health Organization (WHO) estimates that about a quarter of the diseases facing mankind today occur due to prolonged exposure to environmental pollution. However most of these environment-related diseases are not easily detected and may be acquired during childhood and manifested later in adulthood. Toxic pollution occurs when synthetic chemicals are discharged or natural chemicals accumulate to toxic levels in the environment, causing reductions in wildlife numbers, degrading ecosystem functions and threatening human health. Environmental toxicology is a relatively recent field that examines the occurrence of, exposure to, and form of toxicants in the environment, and the comparative effects of these toxicants on different organisms. High-risk groups with maximum exposure should in particular be identified and improved awareness of the sources of pollution in the community would help individuals avoid them. This presentation explains how bio based products have been highly effective yet safe and environmentally sound alternative to the use of organic solvents to pollute the environment.

Key words: Environmental toxicology, Ecosystem, Bio based solvent.

1. INTRODUCTION

1.1. Solvents: Solvents are liquids which have the ability to dissolve, suspend or extract other materials. They make it possible to process, apply, clean or separate materials. Solvents can be broadly classified aqueous (water-based), and organic (hydrocarbon-based) and within each classification, further classifications are necessary to account for differences in structure and physical properties. Solvents have significantly changed modern living and are an invaluable solution for industries as diverse as pharmaceuticals and microelectronics to domestic cleaning and printing. In fact, without solvents, many of the products we use and rely on, from penicillin to industrial paint, would not perform to the standards we demand today.

Solvents from different chemical groups can differ markedly in their characteristics. Organic solvents show varied physiological and toxilogical properties, which all too often are neglected in labs. All solvents affects humans to greater or lesser extent. The extent of this influence depends on the time of exposure. High dose over a short interval of time can lead to acute poisoning; small doses over prolonged period can induce chronic damage.

The main factors which influence the properties of organic solvents are 1)The number of carbon atoms present 2)The presence of only single bonds (saturated molecules) or double or triple bonds (unsaturated molecules) between adjacent carbon atoms, 3) The configuration of the solvent molecule ie. straight chain (aliphatic), branched chain or ring (ie. cyclic and aromatic) 4) The presence of functional groups, eg. –OH, -CN, -NH2 etc. The solvent properties of organic solvents tend to increase with fewer numbers of carbon atoms in the molecule. Unsaturated molecules tend to be more reactive than their saturated counterparts.

2. IMPACT OF SOLVENTS LEADING TO ENVIRONMENTAL POLLUTION

Long term exposure to solvents can lead to deleterious effects on respiratory, haematological and thyroid functioning. Hazardous waste from many industrial processes include solvents such as methylene chloride, a probable carcinogen that is commonly used in paint removers. Trichloroethylene, a solvent that has been found in groundwater. drinking or breathing high levels of trichloroethylene can lead to damage of the liver, lung, and nervous system. The chemical structure of a solvent including any attached functional groups will determine its toxicological properties. Toxicological properties tend to be similar within chemical groupings.

Solvents may also affect other organs in the body. Chloroform and carbon tetrachloride are toxic to the liver. Glycol ethers and some chlorinated solvents may damage the kidneys. Chlorinated organic solvents, such as methylene chloride and trichloroethane are noted for their harmful effects on the heart. Chronic xposure to carbon disulphide is considered a contributory factor in coronary heart disease. Cardiac sensitization may occur following repeated exposure to some solvents. It is due to increased sensitivity of the muscle of the heart to the effects of epinephrine on the rhythm of the heart. It can produce life threatening irregularities in the rhythm of the heart and should be considered as a possible cause of sudden death in otherwise healthy individuals who have been exposed to high levels of organic solvents. It has been reported that the solvents solvent abuse leads to death (eg. Glue sniffing). Although organic solvents readily cross the placenta, most are not considered teratogenic. Notable exceptions are ethanol and some of the smaller chain glycol ethers.

The flammability and explosiveness of a solvent are clearly important determinants of hazard. Measures frequently used to give an indication of the flammability and explosiveness of solvents include the flash and fire points, and the autoignition temperature. Explosive ranges or flammability limits have been determined for different solvents and refer to the concentrations over or above which a particular vapour will burn when ignited. Many organic solvents have low flash points and will burn if ignited. Chlorinated solvents have quite high flash points and are not usually flammable under conditions of normal use.

The following classification is used to qualify the flammability hazard associated with a solvent:

HIGHLY FLAMMABLE flash point < 23°C
FLAMMABLE flash point 23-61°C

COMBUSTIBLE flash point 61-150°C

Some solvents may also be explosive, eg. nitrocellulose. There may also be a risk of exothermic reactions of some solvents with other materials, which may lead to fire or explosion.

The tendency for most organic solvents to evaporate at ambient temperatures and to be absorbed through the skin, the two most important exposure pathways for organic solvents in the workplace are through the lungs and skin. Most petro-chemical solvents and their noxious vapor emissions may cause infertility or birth defectsand should be considered potentially carcinogenic, even if this hazard is not listed on the label, or in material safety data sheets. This is due to the likely presence of traces of benzene and other powerful carcinogens. Virtually all petroleum derived solvents and VOCs known neurotoxins, capable of causing brain and nerve damage.

As we all know that water is such an effective solvent, much toxic pollution that humankind generates eventually ends up in the ocean. After entering the marine environment, many chemical substances concentrate in the sediment and the sea surface microlayer solvents pollute water and are very harmful to aquatic organisms.

The Resource Conservation and Recovery Act (RCRA), enacted in 1976, defines hazardous waste as a liquid, solid, sludge, or containerized gas waste substance that due to its quantity, concentration, or chemical properties may cause significant threats to human health or the environment if managed improperly. U.S. legislation considers a waste hazardous if it is corrosive, flammable, unstable, or toxic. Sources of hazardous waste may include industry, research, medical, household, chemical producers, agriculture, and mining, as well as many others.

Petroleum-derived contaminants constitute one of the most prevalent sources of environmental degradation in the industrialized world. In large concentrations, the hydrocarbon molecules that make up crude oil and petroleum products are highly toxic to many organisms, including humans. Petroleum also contains trace amounts ofsulfur and nitrogen compounds, which are dangerous by themselves and can react with the environment to produce secondary poisonous chemicals.

The U.S. Environmental Protection Agency (EPA) designates six criteria pollutants for determining air quality. These are: carbon monoxide (CO), nitrogen oxides (NO and/or NO_2, usually referred to as NO_x), sulfur dioxide (SO_2), ground-level ozone (O_3), particulate matter (including things like soot, dust, asbestos fibers, pesticides, and metals), and lead (Pb). Petroleum-fueled vehicles, engines, and industrial processes directly produce the vast majority of CO and NO_x in the atmosphere. They are also the principal source of gaseous hydrocarbons (also called volatile organic compounds, or VOCs), which combine with NO_x in sunlight to create O_3. Ozone, while important for blocking ultraviolet rays in the upper atmosphere, is also a key component of urban smog and creates human health problems when present in the lower atmosphere. Sulfur dioxide is a trace component of crude oil, and can cause acid rain when released into the air at oil refineries or petroleum power plants. Particulate matter is directly emitted in vehicle exhaust and can also form from the reaction of exhaust gases with water vapor and sunlight. Leaded gasoline is a huge contributor of lead to the atmosphere, and the use of unleaded gasoline has decreased lead concentrations dramatically.

Petroleum-fueled transportation and coal-burning power plants are considered the chief causes of global warming. Excess amounts of carbon dioxide, methane, and NO_x, among other gases, trap heat in the atmosphere and create the greenhouse effect. Carbon dioxide (CO_2) is a main constituent of petroleum fuel exhaust, even though it is not toxic and therefore not classified as a pollutant. About one-third of the CO_2 emitted into the atmosphere every year comes from vehicle exhaust. Methane (NH_3), although usually associated with natural gas, is also emitted whenever crude oil is extracted, transported, refined, or stored.

3. SOLVENTS IN HOUDEHOLD PRODUCTS AND THEIR EFFECTS

The use of solvents in household products and in arts, crafts, and hobbies has significantly increased the population that may be affected by repeated exposure. However, problems are usually only encountered when the products are used incorrectly or in situations where exposure levels may be higher than normally expected.

Many household products like detergents, furniture polish, disinfectants, deodorizers, paints, stain removers, and even cosmetics release chemicals that may be harmful to human health as well as cause environmental concerns (see the table, "Household Products and Their Potential Health Effects"). Insecticides, pesticides, weed killers, and fertilizers that are used for maintaining one's lawn and garden are another source of household pollution. Their entry into the house could occur through air movement or adsorption by shoes and toys, which are then brought inside the house. A common class of pollutants emitted from household products is volatile organic compounds (VOCs). Sources for these pollutants include paint strippers and other solvents, wood preservatives, air fresheners, automotive products, and dry cleaned clothing. Formaldehyde is a major organic pollutant emitted from pressed wood products and furniture made from them, foam insulation, other textiles, and glues. Exposure to very high concentrations of formaldehyde may lead to death.

4. REMIDIES TO REDUCE THE POLLUTION DUE TO SOLVENTS

The environmental pollution created by solvents will be reduced by using Green Chemistry. The definition of green chemistry can be simply given as: "*The use of chemical products and processes that reduce or eliminate substances hazardous to human health or the environment*". Or "Green chemistry is the design, development, and implementation of chemical products and processes to reduce or eliminate the use and generation of substances hazardous to human health and the environment."

4.1. Green Chemistry Principles

1. Prevention- It is better to prevent waste than to treat or clean up waste after it has been created.

2. Atom economy- Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
3. Less hazardous chemical syntheses- Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
4. Designing safer chemicals- Chemical products should be designed to effect their desired function while minimizing their toxicity.
5. Safer solvents and auxiliaries- The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.
6. Design for energy efficiency- Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.
8. Catalysis- Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
9. Biodegradability- which can be broken down, in a reasonable amount of time, into its base compounds by micro-organisms and other living things, regardless of what those compounds may be.
10. 'Real-time -analysis' for pollution prevention- Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances. **4.2. Usage of green solvents and green methods for synthesis**

Water and water-based systems: Unique solvent properties; Nontoxic, inflammable, odorless; Decreases emissions: Poor solubility into organic phases: easy separation; Unique solvent properties

Supercritical fluids: Supercritical fluids are substances that are heated over the critical temperature (Tc) of the compound and pressurized over the critical pressure (pc) of the compound. The resulting solvents possess the density of liquids and the viscosity of gases. Solvent properties can be altered with minor changes of temperature and pressure Most common in use:scCO_2 and scH_2O

Liquid organic salts: Salts that possess low melting point and are liquids under room temperature. Typically contain quaternary ammonium cations and inorganic anions.

Derivatized and Immobilized solvents: Derivatized solvents are modified solvent molecules that are designed to mimic the solubility properties of original solvent while greatly reducing its volatility. Immobalised solvents are solvent molecules that tethered to a low molecular weight polymer, further reducing its volatility

Solvent free systems: Solvent free systems involves the exposure of neat reactants to microwave irradiations in conjugation with the use of supported reagents or catalysts which are preliminary of mineral origin

Table.1. Household Products and Their Potential Health Effects

Product Type	Harmful Ingredients	Potential Health Hazards
Air fresheners & deodorizers	Formaldehyde	Toxic in nature; carcinogen; irritates eyes, nose, throat and skin; nervous, digestive, respiratory system damage
Bleach	Hypochlorite	Corrosive; irritates and burns skin and eyes; nervous, respiratory, digestive system damage
Disinfectants	Hypochlorite	Corrosive; irritates and burns skin and eyes; nervous, respiratory, digestive system damage
	Phenols	Ignitable; very toxic in nature; respiratory and circulatory system damage
	Ammonia	Toxic in nature; vapor irritates skin, eyes and respiratory tract
Flea powder	Chlordane and other chlorinated hydrocarbons	Toxic in nature; irritates eyes and skin; cause respiratory, digestive and urinary system damage
Floor cleaner/wax	Diethylene glycol	Toxic in nature; causes nervous, digestive and urinary system damage
	Petroleum solvents	Highly ignitable; carcinogenic; irritate skin, eyes, throat, nose and lungs
	Ammonia	Toxic in nature; vapor irritates skin, eyes and respiratory tract
Furniture polish	Petroleum distillates (or) mineral spirits	Highly ignitable; toxic in nature; carcinogen; irritate skin, eyes, nose, throat and lungs
Paint thinner	Chlorinated aliphatic hydrocarbons	Toxic in nature; cause digestive and urinary system damage
	Esters	Toxic in nature; irritate eyes, nose and throat
	Alcohols	Ignitable; cause nervous system damage; irritate eyes, nose and throat
	Ketones	Ignitable; toxic in nature; respiratory system damage
Paints	Aromatic hydrocarbon thinners	Ignitable; toxic in nature; carcinogenic; irritates skin, eyes, nose and throat; respiratory system damage
	Mineral spirits	Highly ignitable; toxic in nature; irritates skin, eyes, nose and throat; respiratory system damage
Pool sanitizers	Ethylene (algaecides)	Irritation of eyes, mucous membrane and skin; effects reproductive system; probable human carcinogen of medium carcinogenic hazard
Toilet bowl cleaner	Chlorinated phenols	Ignitable; very toxic in nature; cause respiratory and circulatory system damage

Table 2. Alternatives to Common Household Products

Product	Alternative(s)
Air refresher	Open windows to ventilate. To scent air, use herbal bouquets, pure vanilla on a cotton ball, or simmer cinnamon and cloves.
Brass polish	Use paste made from equal parts vinegar, salt and flour. Be sure to rinse completely afterward to prevent corrosion.
Carpet/rug cleaner	Sprinkle cornstarch/baking soda on carpets and vacuum.
Dishwashing liquid	Wash dishes with hand using a liquid soap or a mild detergent.
Fabric softener	Use ¼ to ½ cup of baking soda during rinse cycle.
Fertilizer	Use compost and organic fertilizers.
Floor cleaner	Mix 1 cup vinegar in 2 gallons of water. For unfinished wood floors, add 1 cup linseed oil. To remove wax buildup, scrub in club soda, let soak and wipe clean.
Furniture polish	Mix 1 teaspoon lemon oil and 1 pint mineral oil. Also, use damp rag.
Insecticides	Wipe houseplant leaves with soapy water.
Laundry bleach	Use non chlorinated bleach.
Methylene chloride paint stripper	Use nontoxic products.
Oil-based paint, thinner	Use water-based products.
Pesticide	Use physical and biological controls.
Toilet cleaner	Use baking soda, a mild detergent, and a toilet brush.
Window cleaner	Mix ¼ cup ammonia with 1 quart water.

5. CONCLUSION

Pollution prevention by using green chemistry or by any alternative methods will confront the global problem of environmental pollution.

6. REFERENCES

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