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RESEARCH ARTICLE

Harmful Chemicals: Impact on Environment.

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Abstract

Role of Chemicals in human life is very important. They are essential and have adverse impacts on the environment,which has a direct relation with all living things. The three essentials for any life Air , Water and Food which constitutes our environment, are being polluted / adulterated. Our environment is having majority of chemical substances due to various humans activities. It is not the case of today but of the past as well. The difference only lies in the ratio of population verses environment, which is increasing day by day. As a result, there is a direct impact on the physical and chemical environment. These chemicals are the waste from industrial and agricultural processes, structural materials, pesticides, insecticides,weedicides etc.It is evident that some chemicals are useful but many are toxic and harm the environment and our health. A human activity has a complex impact on the environment and affects a chain of interconnecting ecosystems. Use of safe and useful chemicals not only minimizes the risks occurring in the environment but also in human beings.

Introduction:-

Today, globally, chemical pollution has become a serious threat to sustainable development. Both humanity and ecosystems are suffering from the adverse effects of chemicals either through long-term exposure, low or sub-lethal concentrations of certain chemicals / mixtures of chemicals. Becoming economically sound by doing less effort, has become a prime focus today all over the world. The contamination of aquatic environments by pesticides mainly the nitrogen and phosphorous fertilizers are effecting more than 90 per cent of water and aquatic life. Recently there was a report of dying of fishes at river Gomti due to poor BOD (Biological Oxygen Demand). The Oxygen level was decreased because of the contamination due to the dumping of non-degradable waste materials, industry effluents, littering etc. Thunduyil *et al* [1] reported that about 3 % of exposed agricultural workers suffer from an episode of acute pesticide poisoning every year. Chemicals enter in the air as emissions and in water as effluent. The release of chemicals involves many steps in their life cycle. They begin from the extraction of raw materials - through production chains - transport and consumption - to final waste disposal. Their distribution sources mainly are through indoor environments, food and drinking water, soils, and water bodies (rivers , lakes etc.).Certain long-lived chemicals such as persistent organic pollutants (POPs) and heavy metals are transported globally; reaching otherwise pristine environments such as rain forests, deep oceans or polar regions, and can quickly pass along the food chain, bio-accumulating to cause toxic effects in humans and wildlife. Boimagnification of DDT (Dichloro diphenyl dichloro ethane) can be quoted as one of the examples where osprey birds were found to suffer a sharp decline in their population due to increase in its concentration along the food chain through phytoplanktons to zooplanktons and then to fish which was eaten by birds. Today, in the 21st century, one of the major environmental challenges lies with the E-waste, which has also become a major threat to all the living systems. It is found to be the fastest-growing waste stream in the world, with an estimate of 20–50 million tonnes per year (Schwarzer *et al*)[2]. These E-wastes are of particular interest because it contains hazardous substances –

such as heavy metals including mercury and lead ; Brominated flame retardants (BFRs) (endocrine-disrupting substances) and various strategic metals (gold, palladium and rare earth metals) that can be recycled and recovered.

Chemical toxicology:-

It is the study of toxic chemicals and their effects/ modes of action. Once they enter our biological system, they disturb the biological process leading some cases to fatal results. Some useful and important chemicals are being controlled rigorously as their non-toxicity has not been proved. Many metals, in spite of being essential dietary trace elements required for normal growth and development of animals and human beings are also listed as environmental hazards. Even some of the well-known toxic elements Arsenic, Lead and Cadmium are required in trace quantities for the growth of animals. The major cause of Hemodialysis in patients, is due to use of water containing 100-1000 ppb of Al(where alum is used in water treatment plants). In addition biologically inert Aluminum causes brain damage,bone diseases and anemia too in various patient. The classification of Toxic substances can be done according to their functions and effects. A chemical which is hazardous as a result of its acute lethal effects can be classified as:

Oral Dose(Through Mouth): If LD50 < 25mg/kg is absorbed orally in rat, it is very toxic (R28). If LD50 between 25and 200 mg/kg is absorbed orally in rat, it is toxic(R25). If LD50 between 200 and 500 mg/kg is absorbed orally in rat, it is harmful (R22) 3.

Dermal Dose (Through Skin): LD50<5 mg/kg percutaneous absorption in rat or rabbit is very toxic (R27). LD50 between 50and 400 mg/kg percutaneous absorption in rat or rabbit is toxic(R24). LD50 between 400 and 2000 mg/kg percutaneous absorption in rat or rabbit is harmful (R21) 3.

Inhalation Route: LD50 < 0.5 mg/L inhalation in rat per 4h is very toxic (R26). LD50 between 0.5 and 2.0 mg/L inhalation in rat per 4h is very toxic (R23). LD50 between 2 and 20 mg/L inhalation in rat per 4h is very toxic (R20) 3.

Toxic chemicals in air and water:-

Chemicals enter air as emissions and water as effluent. Few examples are as:

Oxides of Carbon Nitrogen and Sulphur [COx, NOx, SOx]:-

Industrial and motor vehicle emissions of nitrogen and sulphur oxides causes acid rain, which poisons fish and other aquatic organisms in rivers and lakes and interferes in the required characteristics of the soil , thereby affecting the ability of soil to support plants. Carbon dioxide lists the top position in causing greenhouse effect and climate change.

Chlorofluorocarbons(CFCs):-

The destruction of ozone in the stratosphere and serious environmental damage from ultraviolet radiation is due to CFCs.

Chemical fertilizers and nutrients:-

The growth of toxic algae blooms (Eutrophication) in the rivers, due to run-off of water from farms and gardens make them uninhabitable to aquatic organisms and unpleasant for humans too. Some toxic chemicals find their way from landfill waste sites into our groundwater, rivers and oceans and induce genetic changes that compromise the ability of life to reproduce and survive.

Organochlorine compounds:-

Polychlorinated biphenyls (PCBs), a well-known Organochlorine compound, were developed originally for use in electric equipment as cooling agents which also falls in the category of dangerous chemicals. They fall in the category of carcinogens where they are capable of damaging the liver, nervous system and the reproductive system in adults. Leakage of millions of gallons of PCB oil during manufacture, resulted in accidents. They accumulate in the food chain of the aquatic systems, where significant levels of them have been found in marine species, particularly mammals and sea birds. Dioxins, a toxic product are formed on burning of PCBs.

Dioxins:-

Dioxins, are a class of super-toxic chemicals. They are formed from chlorine containing organic chemicals and plastics as a by-product during their manufacture, moulding, or burning .It is a very good example of the most toxic man-made organic chemicals known. They cause serious health effects from low level to few parts per trillion. Dioxins accumulate in body fat through the intake of food materials. Their binding process with cell receptors and thereby disrupting hormone functions in the body leads to various genetic disorders. The lack of defensive materials in our bodies against dioxins , causes a wide range of disorders from nervous system to miscarriages to birth deformity to cancer and reduced immunity system. High concentrations of Dioxins have been found near to the sites of their production and on farms, orchards, or along electric and railway lines, where insecticides and herbicides have been heavily used. They are also found from paper mills where bleaching process of wood pulp is done by the use of chlorine chemicals. The evolved traces of Dioxins during its combustion have been carried for hundreds of miles. They settle on pastures and crops and get eaten by herbivores and some carnivores.. They reach lakes, streams, and ocean and are taken up by the aquatic living organisms. Intake of meat and milk products accumulate in the fat cells of our bodies through food chain..

Arsenic:-

The main sources of Arsenic are mainly from mining as by-products, pesticides and chemical wastes and many of its compounds are especially potent poisons. Many water supplies nearer to mines are contaminated by these poisons. Arsenic causes harm by disrupting metabolism at the cellular level.

Cadmium:-

Cadmium occurs naturally in the earth's crust combined with other elements. Cadmium enter into our body by drinking contaminated water mainly through pipe lines, Metal plating, smoking cigarettes, eating contaminated foods and inhaling it by workers during welding, brazing or soldering processes in factories. Cadmium can be acutely toxic to freshwater organisms. On one hand, marine organisms are more resistant to cadmium but people have harmful effects by intake of shellfishes where high concentration of cadmium is present. In view of biochemical effects of Cadmium, it occurs in nature in association with Zinc minerals. Growing plants require Zinc and they also take up and concentrate Cadmium with the same biochemical apparatus.

Copper:-

Copper is an essential trace element. It mainly comes from industrial and domestic wastes, metal plating, mineral leaching etc., not very toxic to animals, toxic to plants and algae at moderate levels.

Lead:-

Lead is a natural element in the environment. Human activities results the most of the lead-related health and environmental problems. The applications of Lead in gasoline, ammunition (household product), and glass manufacturing are very well known. It is a known persistent bio-accumulative toxic chemical, which means its past uses can continue to expose human beings and other living organisms. Lead plays important role in impairing brain development and learning's in children and can affect behavior, growth, high blood pressure and reproduction both in children and in adults. Similarly animal species are also affected..

Mercury:-

Mercury is highly toxic. It is mostly known as a neurotoxin, meaning that it harms the brain and nervous system. However, mercury is also linked to kidney and liver damage and possibly cancer. Children are especially at risk because of their brains and bodies are still developing. Many of the health effects of mercury can be permanent. When it rains, airborne mercury deposits back on the land and water bodies that drain to Puget Sound. Some of the mercury is converted into methyl mercury, a highly stable compound that contaminates our water and our marine life. The methyl mercury concentrates up the food chain, especially in certain fish where it can affect the health of people who eat them. Infants, children and pregnant or nursing mothers must take special precautions to minimize mercury exposure from fish.

Zinc:-

Zinc can kill young salmon as they swim out of their nest gravel. In high enough concentrations, zinc can kill many adult fish species.

Other Harmful Chemicals :-

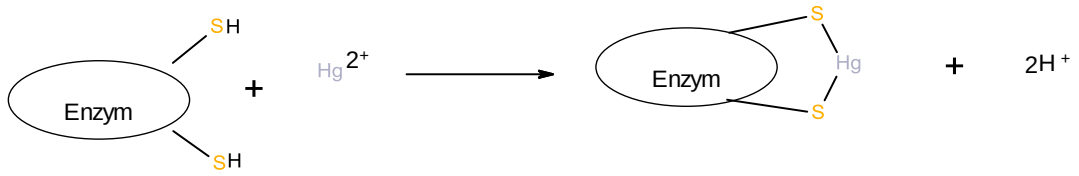
PAHs (polycyclic aromatic hydrocarbons), petroleum related compounds, PBDE (Polybrominated diphenyl ethers) flame retardants, Phthalates e.g. DEHP (Di ethyl hexyl phthalate) , Nonylphenol (found in detergent) are some of the chemicals which cause changes in metabolism of the living species thereby suppressing the immune system. Reproduction and development processes of living organisms are highly targeted and affected. Though Bleaching powder is a useful household cleaning agent but it produces toxic fumes of chlorine gas on reaction with sodium hypochlorite and acids.

Inhale of small amounts results in difficulty in breathing and becomes the cause of permanent respiratory impairment. Significant exposure results in death. Chloramine, household bleach reacts with ammonia, common in many cleaning agents viz. window solution, to produce a series of toxic gases. It is highly caustic, exposure produces respiratory-, skin problem and eye burns. Moderate doses can result Blood poisoning , bluing of the skin caused by lack of oxygen in the blood, and death.

Impact of toxic chemicals on enzymes:-

Active sites of enzymes are the target points of attack for toxic chemicals, thereby inhibiting essential enzyme function.Hg 2+, Pb2+, Cd 2+ are some of the heavy metal ions which act as effective enzyme inhibitors. Their affinity for sulphur containing ligands viz. SCH3 and –SH in methionine and cysteine amino acids which are the part of the enzyme ,results in toxicity.

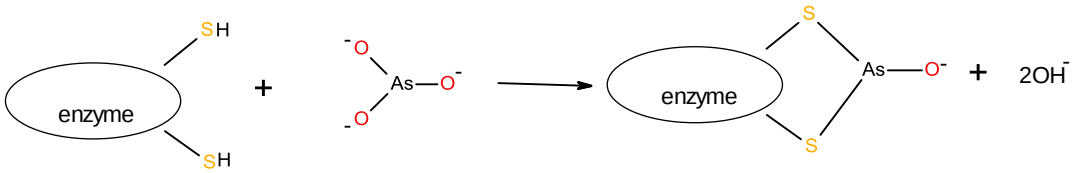
Metalloenzymes contain metals in their structures. Substitution of one metal ion of a metalloenzyme with another ,metal ion of similar charge inhibits their action.For example Zn 2+ in some metalloenzymes is substituted by Cd 2+ leading to cadmium toxicity (Reaction -1).



Reaction -1

Biochemical Effects of Arsenic 4

It commonly occurs in insecticides, fungicides and herbicides. Among its compounds, those of As (III) are the most toxic. As(III) exerts its toxic action by attacking –SH groups of and enzyme thereby inhibiting enzyme action (Reaction -2).



Reaction -2

There is an adverse effect on the enzymes which generate cellular energy in the citric acid cycle. Arsenic interferes with some biochemical processes involving phosphorous. This is observed in the biochemical generation of ATP (Adenosine Triphosphate) a key energy yielding substance. Enzymatic synthesis of 1,3-diphosphoglycerate from glyceraldehyde 3-phosphate. Aresenite interferes by producing 1-arseno-3-phosphoglycerate instead of 1,3-diphosphoglycerate. Phosphorylation is replaced by Arsenolysis which consists of spontaneous hydrolysis to 3-phosphogycerate and arsenate.

Biochemical Effects of Cadmium 4

Growing plants require Zn along with the Cadmium in trace amounts. The outbreak of Cd poisoning occurred in Japan in the form of Itai-Itai disease. The major portion of cadmium ingested into our body is trapped in the kidneys and eliminated (Fig. 1).

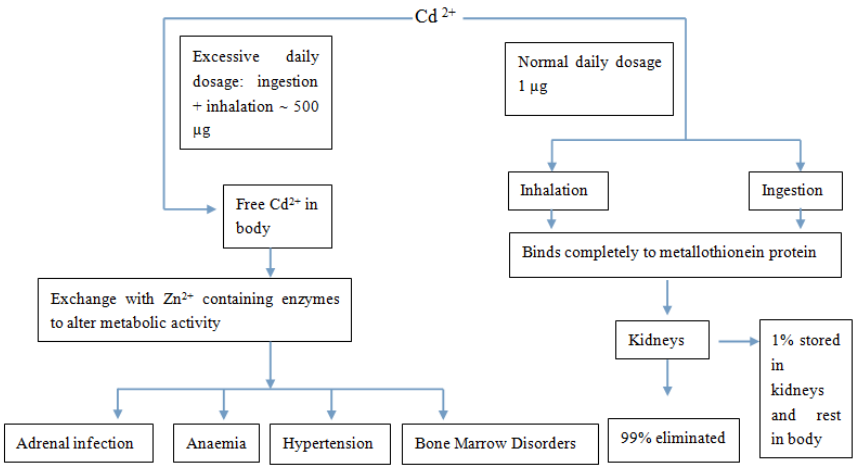
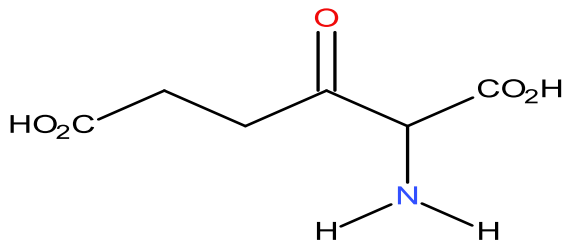


Fig. 1 Metabolism of Cadmium

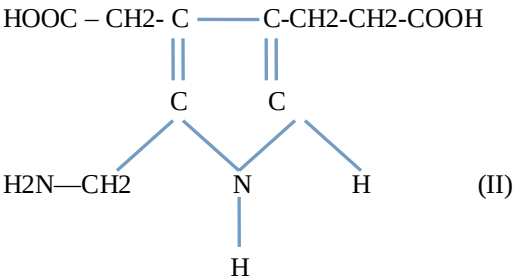
Biochemical Effects of Lead:-

By far the major source of airborne Pb is the combustion of leaded petrol/gasoline. Lead is added in the form of tetra alkyl lead primarily Pb(CH3)4 and Pb (C2H5)4.The major biochemical effect of Pb is its interference with heme synthesis which leads to hematological damage. Pb inhibits several of the key enzymes involved in the overall process of heme synthesis whereby the metabolic intermediates accumulate.One such intermediate is delta-aminolevulinic acid. An important phase of heme synthesis is the conversion of delta-aminolevulinic acid to phorphobilinogen. Pb inhibits the ALA-dehydrase enzyme (I) so that it cannot proceed further to form (II) Prophobilinogen. The overall effect is the disruption of the synthesis of haemoglobin as well as other respiratory pigments such as cytochromes which require heme.Finally, Pb does not permit utilization of O2 and Glucose for life sustaining energy production. This interference can be detected at a lead level in the blood of about 0.3 ppm. The detection of (I) provides a sensitive test for Pb in the body.Elevated Pb levels (> 0.5-0.8 ppm) in the blood cause kidney disinfection and finally brain damage. Dueto chemical analogy of Pb2+ with Ca2+, bones act as repositories for Pb accumulated by the body. Subsequently, this Pb may be remobilized along with phosphates from the bones which exert a toxic effect when transported to soft tissues.



(I)

Delta-aminolevulinic acid (ALA-dehydrase : cytoplasm)

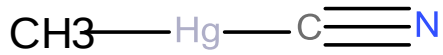


(II)

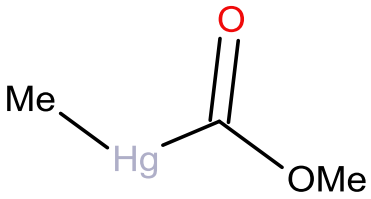
Porphobilinogen

Biochemical Effects of Mercury:-

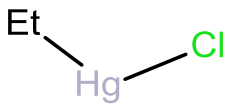
In nature mercury as a trace component of many minerals, continental rocks containing an average of about 80 ppb of Hg. The principal ore is Cinebar, HgS, Fossil Fuels, coal and lignite contain about 100 ppb of Hg. Besides its applications in chlor-alkali industry and in production of electrical apparatus, the third largest consumer is the agricultural industry using a large number of fungicides for seed dressings. Some typical compounds of this category are :



Methylmercury nitrile

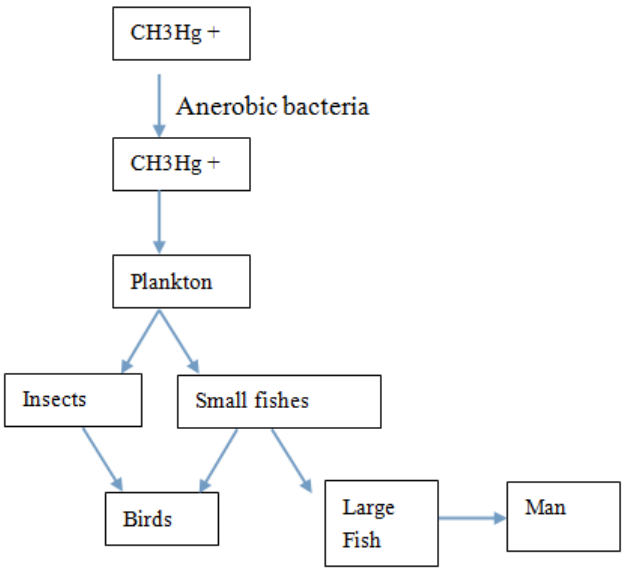


Methylmercury acetate



Ethyl mercury chloride

The impact of seed dressing is enormous since it is applied to a large volume of seed, which is subsequently sowed over millions of acres, thereby causing widespread dispersal of Hg compounds. More often, Hg undergoes translocation in plants and animals and then finds its way into the food chain. Minimata disease is a very good example.



Mechanism of Propagation of Mercury

Conclusion:-

Chemicals are present everywhere in all the materials. The worldwide impact of chemicals on environment is multifold. Chemical toxicity and heavy metal poisoning not only causes the accumulation of toxins in human tissues and organs resulting in some hormonal imbalances, nutritional deficiencies and neurological disorders but also various debilitating chronic conditions and autoimmune disorders too. Thus **Chelation therapy** emerged as the major treatment for the heavy metal toxicity, and various chelating agents have been developed and tested for the treatment of heavy metal intoxications. Researches for progressive steps in this area are been done. Chelation therapy includes the treatment of heavy metal intoxications in human beings with administration of chelating agents, due to the formation of stable complexes with the toxic heavy metal species and prevent them from attacking and damaging biological systems viz. EDTA (Ethylene Diammine Tetra acetic Acid.) method for determination of Hardness of water due to carbonates , bicarbonates, chlorides and suphates salts of Mg^{2+} / Ca^{2+} , is being detected by the chelation therapy using EBT as indicator. The interaction of Pb(II) with the biologically important ligands, can exhibit adverse effects. The loss of functional and structural integrity takes place when Pb^{+2} replaces Ca^{2+} and Zn^{2+} metal ions from their coordination sites. Studies [5] reveal that, besides showing high avidity towards the bio ligands containing sulfhydryl groups, Pb^{2+} also form stable complex with oxygen and nitrogen containing ligands. Today, Green Chemistry is also being focused, as it plays important role as a remedial measure to control Chemical Toxicity.

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