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REVIEW ARTICLE **OPEN ACCESS**

Application of Synthetic Chemicals in Agriculture and their toxic effect on the Environment

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ABSTRACT
This brief review describes the necessity of use of different synthetic organic and inorganic chemicals as fertilizers to increase the production of crops to provide food to all people. It also deals with the application of various types of synthetic organic compounds as pesticides or biocides to save the crops from insects and pests as well as their toxic effect on the living being. The focus of this review is on synthetic organic compounds-especially those that are toxic or can generate other adverse effects in the environment. The nature and environmental properties of them have been discussed through searching their chemistry, stability and way of entrance in the environment. Also, the mechanism of degradation and the chemistry of intermediate during decomposition of some pesticides in the environment have been represented in a very simple way.
Key-Words: *Environment, Synthetic, Agriculture, Soil, Toxicity, Pesticide, Fertilizer, Manure, Zooplankton, Mineralisation.*

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INTRODUCTION

The last century has witnessed development in chemistry and society has come to depend on the products of chemical industry to provide food, other necessities and improve our quality of life. Chemicals and chemical industry affects our life and environment in a number of ways. However, this widespread manufacturing and no judicious application of chemicals particularly in agriculture etc. has resulted in an adverse impact on the nature and environment.

In the 18th century, it was considered that only the inorganic compounds could be synthesised in research laboratory. Organic compounds could not be prepared in the laboratory. Organic compounds are God given gifts and are synthesised in the plants, animals etc. Vital force acts upon living being and organic compound is formed in them. In 1828, Wohler got urea from ammonium cyanate by heating it in the laboratory. Thus, the Vital force theory was discarded. This observation of Wohler started the new era of synthetic organic chemistry. Ammonium salts, ammonia, organic compounds like urea are good fertilizers. These have brought green revolution in agriculture. Synthetic fertilizers saved us from starvation by increasing the production of crops. Organic compounds like D.D.T., B.H.C. etc. have saved the plants from being destroyed by insects and germs. Ultimately, production of crops has been increased. So the use of synthetic fertilizers and pesticides has been appreciated by the farmers. Sometimes, synthetic chemicals are applied in undesirable amount. All these chemicals and salts present in the soil are washed by rain water and discharged into nearby water bodies. Thus water is polluted by the agricultural waste materials and the aquatic life is affected. Finally those toxic chemicals travel in the food chain from lower to higher form of life, viz. from zooplankton through fish to human being and they may get concentrated. This prompted the author to undertake the study on the application of synthetic chemicals in agriculture and their toxic effect on the environment [1,2].

FERTILITY AND NATURE OF SOIL

India is an agriculture base country. To provide food to everyone, there is tremendous pressure on cultiviable land to grow more food and other agricultural products. The production of food and other

agricultural products is largely influenced by the fertility and the nature of soil. Soil is an independent, dynamic body of nature that acquires properties in accordance with the forces act upon it. The properties of soil not only depend upon the type of parent rock but also on the environmental factors like climate, vegetation, topography and time of wreathing or reaction with atmospheric agencies. Soils are composed of two groups of materials, viz. Mineral matter and organic matter. Their properties vary widely according to the percentage ratio of mineral and organic matter. Fertility of soil mainly depends upon the amount of organic matter or humic substance present in it. Humic substances in soil comes from the decomposition products of plants and animal. Organic matter in the soil supplies nutrients to the micro-organism present in the soil.

Plants supply us food, oxygen and other necessities of life. All the animals directly or indirectly live on plants. Thus all animal food including milk is obtained from plants. The plants, so essential for our life require some food for their own nourishment. The food materials build up the body of the plant which contains carbohydrates, proteins, lignin, and other organic matter. Carbon, oxygen and hydrogen are supplied by carbon dioxide and water. The nitrogen is supplied by nitrates, which are ultimately produced in the soil. Some plants may also sustain themselves by ammonia. Plants also require phosphates and potassium salts for their growth. All these plant food are supplied by nature. Carbon dioxide and some moisture are taken from the air, most of the water and salts are taken from the soil by roots of the plants. Oxygenation of the roots and other parts of the plants are also essential for plant metabolism. The food materials derived from the soil are known as fertilizers or manures. Each year these fertilizers are depleted from the soil and they are to be replenished every year. Application of the fertilizers to the soil increases fertility of the soil, hence plant products have to be sustained on normal level by applying larger amount of fertilizers. At the present time, this increase of food production has become urgent owing to the enormous growth of population of the World. Generally, the nitrogenous fertilizers are replenished by the nitric acid produced by lightning, and by the organic manure- the cattle excreta, the plant and animal decomposition products, etc. The phosphates fertilizers are replenished from animal bones, farm yard manure, plant and animal decomposition products.. Potassium fertilizers are replenished by wood ash, and plant decomposition products [2,3].

Different type of fertilizer:

But the natural fertilizers discussed above are limited in amount, moreover much of them are withdrawn from their use as fertilizers, being used as fuel in the countryside(in India) natural source of fertilizers can not cover up with the ever increasing demand for fertilizer for growing two to three crops in a year from a particular piece of a land. Hence it is necessary to add synthetic fertilizers along with farm yard manure to the soil in order to maintain and increase the fertility of the soil. So synthetic ammonia plants have come up in different parts of our country to replenish the deficit by producing urea, ammonium sulphate etc. In India 90% of the ammonia produced is utilised for making nitrogenous fertilizer.

The nitrogenous fertilizers usually used are ammonium sulphate, double salt mixture of ammonium sulphate and ammonium nitrate, ammonium nitrate, calcium ammonium nitrate and urea etc. Other artificial fertilizers used in India are superphosphate of lime, triple phosphate, rock phosphate, ammonium phosphate, ammoniated superphosphate and nitro-phosphate and di-calcium phosphate etc.

Ammonium sulphate is manufactured by first manufacturing synthetic ammonia by Haber process. Ammonia is then allowed to react with sulphuric acid or with gypsum powder and carbon dioxide. Double salt is prepared by mixing ammonium sulphate and ammonium nitrate. Ammonium nitrate is made by the reaction between nitric acid and ammonia. Nitric acid is synthesized by Ostwald's process. Urea is prepared from synthetic ammonia and carbon dioxide. Super phosphate of lime is made by the reaction between rock-phosphate and sulphuric acid. Double superphosphate is prepared by the reaction between rock-phosphate and phosphoric acid [3,4].

Bio- and Mixed Fertilizer:

Bio-fertiliser comes from waste of plant and animal, sewage effluent, sludge, Cow manure, hog manure, poultry manure etc. The main drawback of this bio-fertiliser is that mineralisation by microbes takes long time in soil and action of this fertiliser is very slow. But bio-fertiliser increases moisture holding capacity of soil very much. Also it can improve the soil structure. To increase the fertility of soil frequent use of bio-fertiliser has been suggested. In some countries green manure is also used through cultivation of some plants that can fix nitrogen of air in them. Mixed fertilizer is made by mixing nitrogenous, phosphatic and potassium fertilisers in certain proportion. It is then mixed with fillers. Fillers may be inert matter like sand or organic manure. In India, it is found that combination of organic manure and inorganic fertilizer gives better yield of paddy in some particular type of soil [3].

Application of Pesticides in agriculture:

A group of poisonous organic compounds which are used to increase the production of crops by killing and controlling the growth of unwanted living beings are called pesticides. Unwanted living beings refer

to insects which act as carrier for germs having harmful effect on man, cattle, valuable plants and crops. It also includes insects, rodents, fungus and bacteria which destroy crops, fruits and other food materials. Pesticides may be of various types. Some important types of pesticides may be noted as below to describe their nature and harmful effect on the environment [2,4-7].

Insecticide: Malathion, Parathion, D.D.T., Gammexane, Aldrin, Decamethrin, Aldicarb etc.

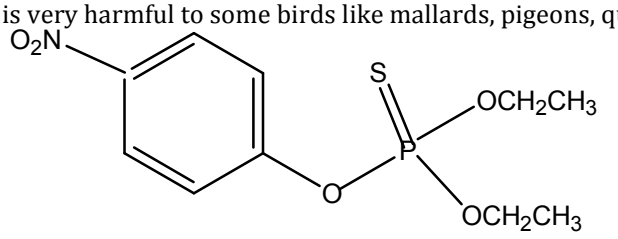
Herbicide: Paraquat, Atrazine.

Acaricide: Malathion, Parathion.

Fungicide: dioxin, Polychlorinated biphenyl(PCB)

Chemical nature of pesticides and toxic effect:

Parathion and Malathion are organophosphorous chemicals. Parathion is O,O-Dimethyl-O-4-nitrophenyl phosphorothioate. It is very harmful to human. It can damage heart, liver, eye and kidney etc. Higher concentration of parathion can damage central nervous system permanently. Parathion may undergo thermal decomposition. It is very harmful to some birds like mallards, pigeons, quail, sparrow etc.



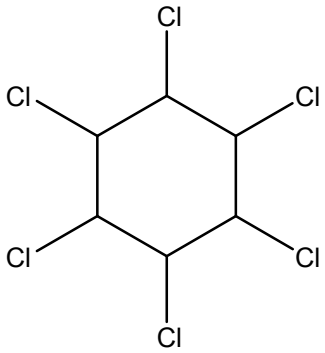
Parathion

Carbamates may be represented by the general formula CH_3-NH-COOR and they may be considered as the derivative of carbamic acid. Two important examples of this class are carbaryl and aldicarb.

Most common organochlorine insecticides are Gammexane, Aldrin, D.D.T. etc. Presence of chlorine in those molecules can impart them extra stability for their long persistence in the environment.

Hexachlorocyclohexane is Gammexane. It is very common insecticide and fumigant. It is moderate toxic compound. It enters into the human system through food and vegetables. In human body , toxicity of this compound varies with its amount. It has harmful effects on kidney, pancreas and mucous membrane of human body. It is stored in animal fat. It can cause mental disbalance also.

In environment, it is very stable compound. It does not undergo photodegradation. It is not destroyed by water. Higher concentration of gammexane in water becomes very harmful to aquatic life.

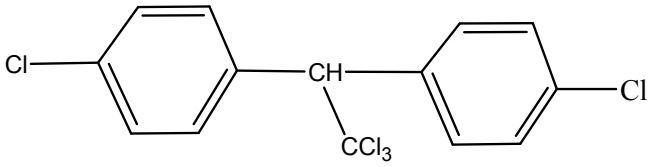


Gammexane

Aldrin is 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-*exo*-1,4-*endo*-5,8-dimethanonapthalene. It is powerful organochlorine cyclodiene. It is a volatile compound with low solubility in water. Through biological oxidation it is converted into a more stronger poison dieldrin. Dieldrin is very persistent compound. These compounds are very toxic to cockroach, grasshopper and other insects. It enters into human system through milk, egg ,fish and other poultry products. It has the power to damage our important organs like liver, kidney etc.

D.D.T. is 4,4'-Dichlorodiphenyltrichloroethane. During second world war, this compound became very important to fight against malaria. D.D.T. is very persistent compound. So It is denoted as persistent organic pollutant. D.D.T. can affect the kidney, liver and nervous system of the human body . It is a contact insecticide and also stomach poison. It acts as a nerve poison affecting Na balance of nerve membranes. D.D.T. is used only where a persistent insecticide is really necessary, otherwise it has been replaced by non-persistent insecticide like Methoxychlor. For its harmful effects, it is banned in the different countries of the world. It can cause cancer in the liver and pancreas.

Presence of D.D.T. water becomes very dangerous to fish and other aquatic life. It enters into human system through fish and other food. D.D.T. gets concentrated in the food chain as it travels from lower to higher form of life, viz. From zooplankton through fish to human being. Zooplankton contains only around 0.4 ppm D.D.T. which has magnified to >75ppm in human being. It is reported that D.D.T. and other organo chlorine insecticide at a concentration of 10 ppb inhibit photosynthesis of some phytoplanktons. This is quite alarming as concentration of D.D.T. in ocean is associated with the survival of its aquatic life.



D.D.T.

Paraquat is 1,1'-Dimethyl-4,4'-bipyridium dichloride, a quaternary nitrogen compound acts as contact herbicide. It can also act as defoliant and desiccant. It is effective herbicide for broad leaf weeds. In human body , it is harmful to heart, kidney and liver etc. but it has no carcinogenic effect. UV light and micro-organism can destroy paraquat. It is moderately toxic to birds.

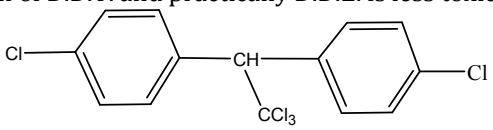
Decamethrin is Cyano (3-pheoxyphenyl) methyl-3-(2,2-dibromoethenyl)-2,2-dimethylcyclopropane carboxylate . It is very powerful Pyrethrins type pesticide. It is used to kill different type sucker . It is also used to destroy different moth. In human body, it may cause swelling of the face, eyelids, and mucous membranes. It can cause respiratory failure. It affects the nervous system and transmission of nerve impulse. Carcinogenic behaviour of this compound is not known with certainty.

Beside above organic pesticides, arsenic compounds find use for their toxicity such as in arsenical insecticide. Arsenic trioxide, As_2O_3 is used as a weed killer and pesticide. Application of organomercury compounds and arsenic compounds as germicides or insecticides is now being discouraged because of environmental pollution [8-12].

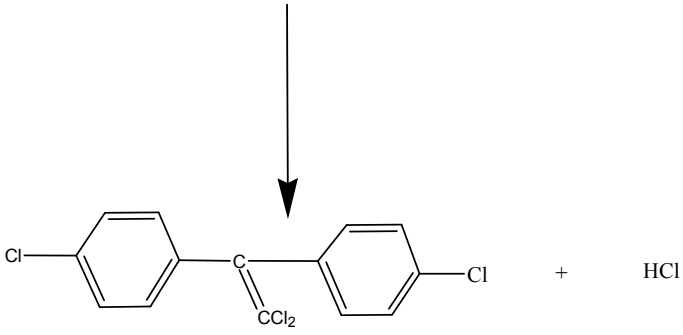
Stability and degradation of pesticides:

To know the effect of synthetic organic chemicals in the environment, two imortant points arise. One of them is the chemical stability of the pesticides and another is mobility of them i.e. transport of them through various compartments of the environment. If chemical stability of them is very low, then degradation will be rapid and mobility will be slow. Degradation of any pesticide into new molecule or intermediate does not mean loss of toxicity. Sometimes, degradation products may be more toxic than original compound [2].

The ultimate degradation products of any synthetic organic compound are carbon dioxide, water along with hydrochloric acid or ammonia that incorporate other elements of the original compound. As these compounds after decomposition are inorganic in nature, it is called mineralisation. During mineralisation so many molecules or intermediates may be formed with various stability and toxicity. D.D.E. is formed during slow decomposition of D.D.T. and practically D.D.E. is less toxic than D.D.T.



D.D.T.



D.D.E.

Removal of chlorine from the original molecule decreases toxicity. On the other hand opposite result is obtained in case of organophosphorus compounds. During decomposition of parathion , paraxon is formed which is more toxic than parathion. The phosphorus atom of paraxon reacts with the acetylcholinesterase enzyme forming a stable complex that inhibits the ability of acetylcholinesterase to catalyse acetylcholine hydrolysis during transmission of nerve impulses. This interference with the neurotransmission accounts for the activity of paraxon as a pesticide and also as a serious potential health hazard to other organisms including humans. This highly toxic form is generated only inside the cell and it is the oxygen containing species which is effective agent in destroying target insects. There are so many types of decomposition reactions. Most common degradation reactions are:

Photolytic degradation in presence of sunlight, hydrolysis e.g. both paraoxon and parathion are subject to degradation via hydrolysis reactions where water molecule acts as a nucleophile, non-photolytic reactions, oxidation and reduction etc. Aldicarb is a potent and broad-spectrum insecticide, acaricide, and nematicide are very susceptible to oxidation. Oxidised products are more toxic than the original molecule as in the case of parathion.

Decomposition of the pesticides in the environment, the rate at which decomposition occurs is also an important feature in determining whether or not the original compound can cause harm to humans or other target organisms. The chemical stability of the substance is also important, but rate also depends on the other reactants, microorganisms and general environmental condition. Photolytic, biotic and abiotic thermal processes can all contribute to the decomposition of the molecule. For individual condition, specific studies are required. The degradation products have their own unique toxicological properties [2, 13-15].

TRANSPORT OF PESTICIDES THROUGH THE COMPARTMENTS OF ENVIRONMENT

Another important factor related to synthetic organic compounds is their capability to move through the compartments of the environment. Pesticides are always sprayed over planted fields or fields with growing plants. It is then in contact with the soil, and rainfall or irrigation water can carry it downward into the soil or laterally into streams and other water bodies. Other organic compounds that are spilled or buried will remain in place or be moved water that is in the soil. So many methods are responsible for their transport, e.g. transport through water, vaporisation etc. organic compounds can move through the soil within both gas and liquid phases. Aqueous phase transport in most cases is the most important. In water, organic chemicals are carried downward by percolating rain and irrigation water, upward by capillary action and laterally on slopes and in ground water aquifers. The mobility of any particular compound depends on the combined properties of a particular chemical and the soil. Gas phase transport is another important method by which pesticides can move vertically or horizontally. Transport across the landscape, in the atmosphere above the soil surface is the significant point of this method. Vapour pressure is the most important factor for any organic compound to be vaporized. Environmental factors affect the rate of vaporisation-most importantly temperature, placement of pesticide in the soil and air currents etc. Strong chemical interaction between pesticides and soil can decrease equilibrium vapour pressure and retard the rate of solid or liquid to vapour transition [2,13,14,15].

CONCLUSION

Nature is the most powerful and best craftsman. The biological reactions of living systems, as devised by nature, are unique, complex and precisely synchronised. Astonishingly enough they do work and life goes on. Nature has devised biological reactions not only to harness solar radiation via photosynthesis by the plants but also to force the plant and animal kingdom to live together cooperatively. This aspect of Nature's strategy has been poorly appreciated by man, as is revealed by our widespread destruction of forests and greeneries. In the name of scientific pursuits the freedom granted to men of science is not unlimited. So nature will not permit any kind of misuse of anything.[8,9]

The progress of the modern society has come to depend on the products of chemical industry. Chemicals and chemical industry affects our life in a number of ways. However, widespread manufacturing of chemicals and misuse of them, particularly in agriculture has resulted in an adverse impact on the nature and environment.

The subject matter of this review is agricultural run off. These generally include the chemicals used as fertilisers and pesticides. Use of pesticides have been appreciated by farmers to increase crop production. In a tropical country like ours, the vegetables and crops are attacked by pests, fungus, bacteria, insects etc. and there is enoromous growth of weed specially during rainy season. So, the use of pesticides, insecticides, herbicides, fungicides is also increasing. In most of the cases, they are misused or they are used in undesirable amount All these chemicals and salts present in the soil are washed by water to affect aquatic life and finally they travel through all compartments of environment.[2]

To be eco-friendly, waste and also the use of toxic and dangerous chemicals should be avoided as much as possible. Compounds which perform better and are easily degradable should be applied in desirable amount in the agricultural field. Use of long persistent and banned chemicals like D.D.T. should be stopped to protect our environment and life.

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