As per UGC guidelines an electronic bar code is provided to seure your paper

International Journal for Modern Trends in Science and Technology, 8(02): 154-158, 2022

ISSN: 2455-3778 online
DOI: https://doi.org/10.46501/IJMTST0802025
Available online at: http://www.ijmtst.com/vol8issue02.html

Role of Chemistry in Agricultural Fertilizers

Dr. Arun Kumar

Associate Professor, Department of Chemistry,Hindu Post Graduate College, Zamania, Ghazipur- 232331, India.
*Corresponding Author: arun.150476@gmail.com

To Cite this Article
Dr. Arun Kumar. Role of Chemistry in Agricultural Fertilizers. *International Journal for Modern Trends in Science and Technology* 2022, *8* pp. 154-158. https://doi.org/10.46501/IJMTST0802025

Article Info
Received: 16 January 2022; Accepted: 11February 2022; Published: 16 February 2022.

ABSTRACT

The basic need of human being is food. It is the agriculture only which fulfills this need for the entire population of the world. Plants are called producers as they synthesize their own food using CO_2 from air and water from soil utilizing sunlight as source of energy by a process known as photosynthesis. The rest of food chain consists of consumers only. The practice of producing crops and livestock from the natural resources of the earth is called Agriculture. Chemistry deals with compounds, both organic and inorganic and agriculture deals with the production of organic product using both organic and inorganic inputs. Thus chemistry forms integral parts of agriculture from molecular to organ level. This review article highlight classification of fertilizers according to their mode of action in the soil, chemical composition of fertilizers, environmental Hazards associated with the use of Artificial Fertilizers.

Keywords: Fertilizers, Plant Growth Hormones, environment hazards of artificial fertilizers, natural fertilizers.

1. INTRODUCTION

Chemistry is an important tool in our daily lives. Almost everything is made up of Chemistry. Chemistry is important because it helps us understand the structure, composition and changes of matter. All matters are made of Chemistry. Chemistry is the Science behind the production of most of the agricultural products that we mostly use, from the production of food to production of products like fertilizers.

The history of life on earth has been a history of interaction between living things and their surroundings. To a large extent, the physical form and the habit of the earth's vegetation and its animal life has been moulded by the environment considering the whole span of earthly time, the opposite effect, in which life actually modifies its surroundings, has been relatively slight. Only within the moment of time represented by the present century has one species - man - acquired significant power to alter the nature of his world.

Modern agriculture is a complex scientific activity involving biotechnology and high levels of mechanisation, large inputs of energy in the form of increased irrigation, fertilizers and pesticides. There has been a marked increase in our agricultural production mainly due to the application fertilizers and pesticides. Chemistry and chemical industry plays an important role in the development of these synthetic materials. Large number of inorganic and organic compounds were synthesized and tested for their effectiveness as agrochemicals in the past few decades. The agrochemicals which are applied to the soil to increase

soil fertility are termed fertilizers and those which are used in pest management are called pesticides.

2. FERTILIZERS

Plants require about sixteen elements such as carbon, hydrogen, oxygen, nitrogen, potassium, phosphorus, calcium, magnesium, sulphur, zinc, boron, copper, manganese, molybdenum, chlorine and iron for their growth. Out of these elements carbon, hydrogen and oxygen are derived from air and water and so these are called natural nutrients. Nitrogen, phosphorus and potassium are consumed in large quantities by plants for their growth and are called primary nutrients. Calcium, magnesium and sulphur which occur to a limited extent in all soils and are consumed in small quantities by plants are called secondary nutrients. Rest of the elements boron, copper, iron, manganese, molybdenum, zinc, and chlorine are called micro nutrients. They are essential for plant growth but needed only in very small quantities and so these elements are also called trace elements.

To be available to plants, the above mentioned elements must be present in the soil in some chemical combination which is water soluble at least to a limited extent. After repeated cultivation, a stage is reached, when the soil become deficient in these elements and plant growth is retarded. A soil is said to be fertile or productive if it can provide the necessary nutrients required for plant growth. In order to make up the deficiency of nutrients and to increase the fertility certain elements in the form of their compounds are added to the soil. These substances are called fertilizers. Thus, fertilizers are substances which are added to the soil to increase the fertility and to remove the deficiency of essential elements required for plant growth.

3. CLASSIFICATION OF FERTILIZERS

Fertilizers are classified into various types on the basis of their mode of action in the soil are given below-

1. Direct fertilizers

These are fertilizers which are absorbed directly by the plants from the soil. They contain nutrient elements in the form of soluble mineral salts which can be easily assimilated by plants. According to the nutrient element present, these may be nitrogenous, phosphatic or potash fertilizer.

Examples:

(i) Nitrogenous fertilizer - Urea

(ii) Phosphatic fertilizer - Super phosphate

(iii) Potash fertilizer - Muriate of potash

These are also called straight fertilizers.

2. Indirect fertilizers

These are substances which have no direct value for the growth of plants; but produce indirect effects by their presence and keep the soil suitable for plant growth. For example, gypsum ($CaSO_4.2H_2O$) helps in converting the insoluble potassium salts in clay soils to more soluble potassium compounds. Lime and calcium carbonate change the insoluble phosphate of iron and magnesium to more soluble calcium phosphate. Lime and $CaCO_3$ also neutralise the acidity of soil.

Some of the salts such as sodium carbonate present in the soil is harmful to plants. Such salts are converted to less soluble compounds by the addition of lime, gypsum or calcium carbonate. Indirect fertilizers keep the soil fertile by keeping the soil loose, allowing free circulation of air, neutralising the acidity of soil and facilitating the growth of soil microorganisms.

3. Complete fertilizers

Complete fertilizers contain all the essential nutrients for the growth of plants, in a combined form so that no additional fertilizer is needed. Complete fertilizers contain nitrogen, phosphorus, potassium and mineral salts. Example of a complete fertilizer which is naturally available is guano (excreta of sea birds). Complete fertilizers can be manufactured artificially. Compost, the organic manure mixture containing all essential nutrients, is actually a complete fertilizer.

4. Incomplete fertilizers

These contain only one or two elements required for the healthy growth of plants. If certain soil contains all the necessary nutrients except one or two, then these are supplemented by adding one or more of the incomplete fertilizers. Many of the direct fertilizers are incomplete fertilizers.

Examples:

(i) Urea or ammonium sulphate - provides nitrogen only

(ii) Ammonium phosphate provides nitrogen and phosphorus.

4. NATURAL INORGANIC FERTILIZERS

The important naturally occurring inorganic fertilizers are:

(1) Potassium salts and (2) Rock phosphates.

1. Potassium Salts

Potassium in one or other form is indispensable to plant growth and agricultural production because potassium ions help the production of starch and other forms of carbohydrates. The important natural sources of potassium are wood ash and waste materials of sugar beet crop. Wood ash contains about 5% potassium as K_2O. Potassium ions not only increase crop yield but also enable plants to resist diseases.

In addition to wood ash and waste materials of sugar beet crop, the following potassium salts are also used as fertilizers:

(a) Potassium nitrate, KNO_3

Potassium nitrate, or nitre or salt petre occurs in the soil of many tropical countries. This soil is removed and extracted with water. Then the salt is crystallized out. It has the advantage that it can provide both potassium and nitrogen to the soil.

(b) Potassium chloride, KCI

The important source of KCI is the uppermost layer of the Stassfurt deposit called carnalite, $KCI.MgCl_2.6H_2O$.

Potassium chloride is also extracted from the water of certain lakes rich in KCI and from Dead Sea brine by evaporation. KCI is commercially known as muriate of potash (M.O.P) and its potassium content varies from 50 to 55%.

(c) Potassium sulphate, K_2SO_4

It is manufactured from naturally occurring minerals, e.g., schonite, $K_2SO_2.MgSO_4.6H_2O$ Potassium sulphate is mainly used as a fertilizer for tobacco and wheat.

2. Rock phosphates

Apatite is the principal mineral in the important phosphate rock deposits of the world. Apatite is represented as $Ca_{10}(PO_4)_6(F,C1,OH)$. Fluorapatite, $Ca_{10}F_2(PO_4)_6$, which is a particular apatite, occurs mainly in conjugation with $CaCO_3$ in a mineral called francolitite, $Ca_{10}F_2(PO_4)_6xCaCO_3$.

Finely divided rock phosphate, although insoluble in water, weathers rapidly into soluble phosphates which can be utilised by plants. *Mussooriephos* is the rock phosphate taken out from Mussoorie mines of U.P. Bone meal is another natural inorganic fertilizer supplying phosphorus. Phosphorus is expressed as the amount of P_2O_5 available from the sample of the given fertilizer. Phosphorus is very important to plants in the development of roots and also in the ripening of fruits.

5. SYNTHETIC (ARTIFICIAL) INORGANIC FERTILIZERS

These are the artificially prepared salts or mixture of salts. They are classified into nitrogenous fertilizers, phosphatic fertilizer and potash fertilizers based on the element (nitrogen, phosphorus, or potassium) they supply to the soil. Modern agriculture greatly depends on these synthetic fertilizers for better crop production.

1. Nitrogenous Fertilizers

Even though nitrogen is the most abundant element in the atmosphere, it is not available to most of the green plants. A very small portion of the atmospheric nitrogen is converted to available nitrogen through the process of nitrogen fixation. Nitrate (NO_3^-) is the principal form of nitrogen utilized by plants. Nitrates are highly water soluble and not adsorbed to soil particles. Hence they are leached away easily along with land run off. Consequently soil becomes deficient in available nitrogen. To make up this deficiency, nitrogenous fertilizers are added to the soil. Some of the important nitrogenous fertilizers are ammonium sulphate, ammonium phosphates, calcium cyanamide and urea.

(a) Ammonium sulphate, $(NH_4)_2SO_4$

Ammonium sulphate contains about 21% nitrogen. It is slow in its action, since it has to depend upon soil bacteria for its conversion to nitrate. In this process, it releases sulphate ions and the acidity of soil increases due to the accumulation of sulphate ions. Lime has to be added to decrease the soil acidity.

Ammonium sulphate is the principal nitrogenous fertilizer manufactured in India. The Sindri Fertilizer Factory in Bihar is probably the largest ammonium sulphate factory in Asia. It is also being manufactured by Fertilizers and Chemicals, Travancore (FACT) in Kerala.

(b) Ammonium phosphates

These are important synthetic fertilizers supplying both nitrogen and phosphorus to the soil. The most common ammonium phosphates are ammonium dihydrogen orthophosphate $(NH_4)H_2PO_4$ and diammonium hydrogen phosphate $(NH_4)_2HPO_4$.

(i) Ammonium dihydrogen orthophosphate, **$(NH_4)H_2PO_4$**

This is also called mono ammonium phosphate (MAP). It contains about 12% nitrogen and 50% phosphorus as P_2O_5.

(ii) Diammonium hydrogen phosphate, **$(NH_4)_4HPO_4$**

This is also known as diammonium phosphate (DAP), containing nitrogen and phosphorus in almost equal proportions and is an excellent fertilizer. It contains20% nitrogen, 20% phosphorus and 15% sulphur in sulphate form.

(c) Calcium cyanamide, **$CaCN_2$**

Calcium cyanamide mixed with carbon is called nitrolim and is used as a nitrogenous fertilizer. Due to slow conversion of it into ammonia and nitrate, it is a good fertilizer as its effects are of prolonged nature.

In the soil, it first changes into calcium carbonate and cyanamide.

$$CaCN_2 + H_2O + CO_2 \longrightarrow CaCO_3 + \underset{\text{cyanamide}}{H_2N.CN}$$

The cyanamide then undergoes hydrolysis to urea and then to ammonia.

$$H_2N.CN + H_2O \longrightarrow \underset{\text{urea}}{H_2N.CO.NH_2}$$

$$H_2N.CO.NH_2 + H_2O \longrightarrow 2NH_3 + CO_2$$

Ammonia formed in this manner is finally converted to nitrates by nitrifying bacteria. Calcium carbonate formed in the process is also useful from the agricultural point of view. Nitrolim contains about 21% of nitrogen.

(d) Urea, **NH_2CONH_2**

Urea is a very good synthetic nitrogenous fertilizer containing about 46% of available nitrogen. It can be applied to all crops and soils. In the soil, urea is first hydrolysed to ammonia and carbon dioxide by soil water.

$$CO(NH_2)_2 + H_2O \quad CO_2 + 2NH_3$$

Nitrosification of NH_3 to nitrites takes place by the action of bacteria such as *Nitrosomonas* and *Nitrosococcus* in the soil.

$$2NH_3 + 3O_2 \xrightarrow{\text{bacteria}} 2NO_2.2H_2O + 2H^+$$

Nitrification of nitrites is brought about by *Nitrobacter* bacteria to form nitrates in the soil which are utilised by plants.

$$2NO_2^- + O_2 \xrightarrow{\text{bacteria}} 2NO_3^-$$

Thus, urea is the best amongst all the nitrogenous fertilizers, because after being assimilated by plants, it leaves behind only CO in the soil which has no harmful effects.

6. ENVIRONMENTAL HAZARDS ASSOCIATED WITH ARTIFICIAL FERTILIZERS

Artificial Fertilizers

Modern agricultural practices largely depend on artificial fertilizers for better crop production. Even though its controlled application is useful for soil fertility and plant growth, the long-term and excessive application of synthetic fertilizers may cause several environmental hazards.

Long term use of artificial fertilizers may contaminate the soil with various impurities like other synthetic organic pollutants or heavy metals which may be present along with these fertilizers. Impurities in fertilizers include metals like Cd, Cr, Mo, Pb, U, V, Zn etc. Phosphatic fertilizers usually contain cadmium and uranium. These impurities may get accumulated in the soil and will cause pollution problems.

Large quantities of nitrates and phosphates are washed away from fertilized lands during rain and may reach various water bodies. In terms of water quality, these nutrients can be considered as pollutants when their concentrations are sufficient to allow excessive growth of aquatic plants, particularly algae. Nutrient enrichment can lead to blooms of algae, which eventually die and decompose. Their decomposition removes oxygen from the water, leading to levels of dissolved oxygen that are insufficient to sustain normal aquatic life. This process of nutrient enrichment leading to algal bloom and consequent decrease in dissolved oxygen and water quality is termed ***eutrophication***.

7. CONCLUSION

Chemistry has been and is still closely linked to the progress in agriculture field. It provides innovative new ways to widen the boundaries. of agriculture and to combat potential problems. Modern agriculture depends quite heavily on the advances that have been made in Science, and Chemistry in particular to maximize the yield of crops. A fertilizer is a plant nutrient added to soil to increase its fertility. Plants need nutrients to grow and produce fruits and vegetables. There are two categories of nutrients required for fertilization, macro and micronutrients. Chemists discovered that of these nutrients, nitrogen,

phosphorus, potassium, sulfur, magnesium and calcium are important in plant growth. Most popular fertilizers contain three major nutrients, nitrogen, phosphorus and potassium. But on excessive use of artificial fertilizer may causes several environmental hazards also causes soil pollution.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] G.D. Gem Mathew; Chemistry in Everyday Life, 2nd Edition, Vishal Publishing Co. Jalandhar,2017.

[2] V.K. Chhibber; Role of Chemistry in Agriculture, BFIT

[3] K. Singh, Chemistry in Daily Life, Prentice Hall of India, Mew Delhi 2008.

[4] A. Gopinath; Chandradasan; Environmental Chemistry, 2nd Edition; Vishal Publishing.Co. Jalandhar, 2016.

[5] A.K. De; Environmental Chemistry, New Age, New Delhi, 2006.

[6] H. D. Crone; Chemicals and Society. - A Guide. to the New Chemical Age; Cambridge. University Press, London, 1986.

[7] C.H. Snyder; The Extraordinary Chemistry of Ordinary Things; John Wiley & Sons, Inc., New York, 2007.

[8] H. Free; Your Chemical World: American Chemical Society, Washington DC, 1996.

[9] CSIR, Golden Jubilee Series, National Institute of Science Communication and Information Resources (NISCAIR), CSIR, New Delhi, India.

[10] M. K. Jain, S.C. Sharma, Modern Organic Chemistry, Vishal Publishing Co. Jalandhar, New Delhi, 2009.