

Role of Analytical Chemistry in Pharmacy, Agriculture and Environment - A Review

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ABSTRACT

Analytical chemistry is the branch of chemistry which deals with the analysis of chemical substances of all sorts. Analytical chemistry plays an immense role in the different branches of sciences and other field such as Pharmacy, Agriculture, Industry, Environmental Science, Physical Science, and Biology etc. For the analysis of the chemical substances elements present in the sample under observation. Analytical chemistry plays a vital role in the pharmacy for the analysis of assay and purity of the drugs for this there are so many instrumental techniques were used such as titrimetric, chromatographic, spectroscopic, electrophoretic methods of chemical analysis. Similarly In the agriculture there are so many analytical methods are used for different purposes such as for the soil testing, analysis of fertilizers, pesticides and inorganic and organic traces of analysis. Analytical chemistry also played a major role in Industries and environment such as in Industries for the quality control of the industrial material there is need of analytical chemist and different chemical and instrumental analytical techniques. Analytical Chemistry is the heart of the environmental analysis such as the analysis of air, water soil, industrial effluent which is helpful in the controlling the pollution which is adverse to the life on the earth. In the present study we try to put forth the brief review about some of the routine and advanced analytical methods used in the above mentioned disciplines and its role for the development of the concerning discipline.

Key Words: Assay, Chromatographic, Spectroscopic, Titrimetric, Soil Testing.

INTRODUCTION

'Analytical chemistry is the science concerned with the systematic identification or characterisation of established chemical species and their determination to known degrees of certainty at any level of concentration and in any matrix in which they may occur'. Pharmacy is one of the subjects where analytical chemistry is studied vastly. It is used for purposes like checking the quality of inorganic compounds, organic compounds, drugs and other useful chemicals. It is mostly used for the purposes like application analytical chemistry in pharmacy to determine shelf life, the dissolution studies and contaminants [1-10].

To determine self-life of compound. Self-life is the time period till which a compound will be fit for use. For medicines, it is the time required for 90% of drug ingredient to stay active after the date of manufacture. Hence we notice expiry date clearly marked on all the medicine packages. So in pharmacy we notice some medicines stored in refrigerator and some in dark places to maintain the self-life. To determine adulterants: During manufacture of drug, there are many chemical intermediates and reagents used. So there are many chances that impurities like heavy metals, dirt etc. can also be present in final preparation. Analytical chemistry is used to see if the formulation is within limits of contamination. If the contamination is more, then it is unfit for consumption [10-20].

Drug dissolution studies: When a medical formulation is made in the form of a tablet, ointment, capsule etc. It is tested for its ability to release the medicine from within when put in a suitable medium. The dissolution studies are done to see if the medicine is released completely from the tablet. Also the time taken for release. Both these factors are essential because when a tablet is swallowed, it stays in the stomach only for an hour. So if it has to release the medicine, it has to do it within one hour. Also a medicine shows its effects at suitable dose and not sub-doses. So the tablet has to release the entire content within the said time. Hence dissolution studies are done by using analytical chemistry to test the release of drug from a formulation. It is also used as a part of medicinal chemistry for qualitative and quantitative analysis [20-35].

The pharmacology is the clinical science which is very important for maintaining the health of the human being, analytical chemistry plays a crucial role in the development of pharmaceutical. For the cure disease we require the

drug which has a better therapeutic value. Drug development is the innovation of the drug molecule which pharmacologically active or which contains active pharmaceutical ingredients (APIs) . Analysis of such drug molecule creates preliminary safety and therapeutic efficacy data are prerequisites to identification of drug candidates for further detailed investigation (Valagaleti et al., 2003). The drug which is soluble in the blood and it reaches all the part of the body after administration to the victim and which is non-toxic as well as has no adverse effect on the health of the victim is known as a successful drug. The efficacy and safety of the drug is depends upon the active pharmaceutical ingredients contain in the given drug molecule. The drug being pharmacologically active due to presence of some pharmacophoric functional group or chiral centre[36].

EXPERIMENTAL PROCEDURE

Development of drug involves the investigation of the bulk drug materials, intermediates drug products, drug formulations, impurities and degradation products. Now days the methods used for the characterization and Qualitative and Quantitative analysis of the drug, with the help of some analytical methods such as titrimetry, spectrometry, chromatography and capillary electrophoresis as well as some electro analytical techniques are also used. Analytical chemistry plays a major role in the pharmacy by the using following analytical techniques.

Titrimetric analysis: Titrimetric analysis was developed in the middle of 18th century after the invention of term volumetric titration in 1835 by Gay-Lussac. Assay methods is an old method of analysis but some modernization is found i.e. non-aqueous titration method, acid base titration with the help of potentiometric titration determination of end point increases precision of the method. In the past titrimetric methods was used for the determination of captopril (Rahman et al., 2005a), and gabapentin (Sameer and Abdulrahman Basavaiah, 2011) in commercial dosage forms. Sparfloxacin (Marona and Schapoval 2001) was determined by the non-aqueous titration method. In addition to its application in drug estimation titrimetry has been used in the past for the estimation of degradation products of the pharmaceuticals [37-39].

Chromatographic Techniques: chromatography is the one of the analytical techniques which is widely used in the pharmaceutical industries for the separation and purification of the drug molecules. (Matei et al 2008). There are various types of chromatographic techniques were used in the pharmacy such as, Thin Layer Chromatography (TLC), High performance thin layer chromatography (HPTLC), High performance Liquid Chromatography (HPLC) etc. were used in the chemical analysis in the pharmacy. TLC technique is old technique but it found lot of application in the pharmaceutical analysis. In TLC there two phases one is mobile phase which liquid while another one is the stationary phase which is solid absorbent such as alumina (Al₂O₃) Charcoal (C), Florisil (MgO/SiO₂) and Silica (SiO₂). TLC is a powerful tool for screening unknown materials in bulk drugs (Szepesi and Nyiredy, 1996). It provides a relatively high degree of assertion that all probable components of the drug are separated. The high specificity of TLC has been exploited to quantitative analytical purpose using spot elution followed by spectrophotometric measurement. TLC has been utilized for the determination of some steroids (Cimpoi et al., 2006), pioglitazone (Gumieniczek et al., 2004), celecoxib (Bebawy et al., 2002) and noscapine (Ashour et al., 2009) [40-45].

High performance thin layer chromatography is highly faster and flexible techniques for the analysis of wide varieties of the sample. HPTLC was used to analysis of the ethinyl esteradiol and cyproterone (Pavic et al., 2003) Alfuzosin (Fayed et al., 2006) and tramadol, pentazocine (Ebrahim et al., 2011). Similarly high performance liquid chromatography and gas chromatography are used for the purification separation of the drug molecules. There are so many analytical techniques used are tabulated in the bellow table. 1 [46-48].

Table 1 Proportion of various analytical methods prescribed for the assay of bulk drug materials in Ph. Eur. 4 and USP XXVII.

Sr. No.	Methods	Ph. Eur. 4%	USP 27%
1	HPLC	15.5	44
2	GC	2	2.5
3	Titration	69.5	40.5
4	Acid- base	57.5	29.5
5	Aqueous mixture	21	5.5
6	Indicator	6.5	4.5
7	Potentiometric	14.5	1
8	Non-aqueous	36.5	24
9	Indicator	9.5	14
10	Potentiometric	27	10
11	Redox (Iodometry, Nitrometry(etc)	6.5	5.5
12	Other (complexometry, argentometry etc.)	5.5	5.5

13	UV-Vis spectrophotometry	9.5	8.5
14	Microbiological assay (antibiotics)	3	2.5
15	Other (IR, NMR, polarimetry, fluorimetry, atomic absorption spectroscopy, Polarography, gravimetry etc.)	0.5	2.0

Source: S. Gorog/Journal of Pharmaceutical and Biomedical analysis 36 (2005) 931-937.

There are so many analytical instrumental methods were used for the chemical analysis of drug in the pharmaceutical. These methods are spectroscopic techniques such as UV-Vis spectroscopy for the determination of conjugation in the structure of the drug molecule; it is specially applied for the analysis of pharmaceutical dosage. The colorimetric methods are usually based on the complex formation reaction, Oxidation-reduction process, A catalytic effect. Nuclear magnetic resonance (NMR) spectroscopy is also one of the spectroscopic methods used for the analysis of the drug molecule. NMR finds the application in the quantitative analysis of purity of the drug molecule (Mistry et al., 1999), Many reviews on the application of NMR in pharmaceuticals have been published (Holzgrabe et al., 2005; Malet-Marting and Holzerabe, 2011). Fluorimetry and phosphometry: Fluorimetry and phosphometry are the most sensitive methods for the precise analysis of the drug. There are so many articles on the application of the fluorimetry (Rahman et al., 2012;2009) and phosphometry (De Souza et al., 2013; Chuan et al.,2000). Similarly electro-analytical techniques such as conductometry, potentiometry, amperometry etc. were used for the chemical analysis. In this way analytical chemistry plays vital role in the pharmaceutical analysis. [49-54].

Role of Analytical Chemistry in agriculture:

Analytical Chemistry plays important role in the organic and inorganic analysis in the agricultural research for the analysis of micronutrients in the soil. Soil testing is done to study the inorganic and organic minerals in the soil. This tells how far the soil is suitable for growth of particular crop. It also gives an idea of microbial environment, fertility and pesticide residues in the soil. In the agriculture for the determination of the soil quality whether it is fertile or non-fertile which type of the micronutrients present and which type of fertiliser should be applied is analysed by means of soil testing and soil analysis with the help of electro-analytical techniques like PH metre. Water testing: Not all water is suitable for growth of crops. Some of the water is very hard that it deposits lime on the fertile soil making it unfit for further cultivation. By analytical chemistry one can analyse the water for its constituents and make suitable changes to it. Harvested crop testing. Once the crop is harvested, it is tested for its quality in terms of the pesticide residues, any contaminants etc. If the material has high amount of pesticide or other waste, it is rejected for human use.

The main role of analytical chemistry in the agriculture is that protect farmer from frauds during the buying the fertilizers and pesticides. Only legal fertilizers and pesticides which are authorized by the analytical chemistry laboratory for its active component. The green revolution for increase in crop yield is the outcome of agricultural research with the help of analytical chemistry. In twentieth century the concept of preservation of soil fertility became declared goal of agriculture research. Challenges were demanding but fascinating to detect the pollutants analytical methods were used for the analysis of inorganic and organic pollutants. Agricultural research is depends upon the analytical chemistry e.g. for the determination of element in the plant extract after extraction is the important task for the analytical chemistry to determine minor constituent in the given extract for this purpose analytical methods were applied.

Inorganic analytical Method: There are many inorganic analytical methods were used in the agriculture based on the physical methods except the electrochemical methods used for the determination of pH and fluoride in the soil extract. Nitrogen in the soil is determined by means of Dumas or Kjeldahl method. Further this method is replaced by most efficient technique Near Infra-red spectroscopy (NIR) as well as more advanced techniques such as photometry, atomic absorption spectrometry, Flame photometry, electrothermal atomiser absorption spectrometry, Atomic emission spectrometry with coupled plasma (ICP-AES) were used for the multi element analysis

Organic Trace Analysis: In the organic trace analysis analytical chemistry plays an immense role in the analysis of the organic compounds distributed in the agricultural system such as both receiver and emitters. There is thousands of anthropogenic organic compounds currently in use but mainly they are divided in three main groups.

1. Persistent organic pollutant, 2. Classical pesticides and 3. Emerging compounds such as veterinary pharmaceuticals representative of such groups are a) polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), b) organochlorine pesticides and triazines, and c) veterinary antibiotics such as the tetracycline. Whereas group b) and c) compounds are usually primarily emitted by agricultural activities, group

a) pollutants are introduced into agricultural systems via, e.g. atmospheric deposition or sewage sludge's. For the analysis of such pollutant classical Soxhlet extraction is used. For the separation and detection GC/MS or LC/MS

techniques were used.

The role of analytical chemistry in the environment:

Over the past decade there is an increase in the awareness among the people about need for environmental protection. Due to this number of planes and direct and indirect action taken by the authorities to assure that the new and old industries were limitation is apply for the discharge of gaseous, liquid and solid waste and their handling of dangerous substances. Some controls are achieved through direct legislation, others through conditions attached (a) by local authorities to the granting of planning applications and to the awarding of IDA grants. In all areas of environmental protection, the analytical chemist is intimately involved because almost every control or regulation relates to permissible concentration levels of substances which may be present in discharges, effluents, etc. Their analysis is therefore a prerequisite to the effective implementation of those controls and regulations.

In the environment analytical chemistry plays a important role because there are many analytical instrumental methods were used to determine the air quality in the environment, water quality in the environment as well as for the analysis of the pollutant. Pollution is the serious matter which hazards the control healthy environmental condition. There are many types of instrumental and non- instrumental methods of chemical analysis were used in the environmental sciences such as for the water and air analysis chemical as well as electrochemical methods are used. For the analysis of soil micronutrients and pollutants different spectrometric methods are used. So analytical chemistry plays vital role for study of air condition (pollution), water and soil contents in a particular locale.

CONCLUSIONS

From the beginnings till now, analytical chemistry has always played an important role in pharmacy without analytical chemistry one can not imagine development of pharmacy, Agriculture and Environment. Indirectly analytical chemistry plays a vital role in the maintaining health of the society with the development of Pharmaceutical in pharmacy, food by agriculture and pollution free healthy environment. With the help of many modern analytical Qualitative and Quantitative and instrumental methods of analysis one can able to analyse weather drug sample, soil sample, air sample as well as water or any sample which helps in getting information about its contain and contamination. Over all analytical chemistry plays an immense role in the analysis and maintain the quality of the product.

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