

Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) for Pollution Monitoring

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Lecture – 01

Course introduction and atomic structure – I

Dear participants, greetings to all of you, I am going to give you a course on inductively coupled plasma atomic emission spectrometry and that is known as ICP AES for pollution control and it is also known as ICP OES inductively coupled plasma optical emission spectrometry. But more importantly it is known as ICP AES and regarding the this course I would like to show you one more slide that is it is basically a template in which I introduce you to the actual course regarding the plan of teaching.

Actually I could have shown you at the end of, my plan was to show it to you at the end of the presentation, but I think it is a right time to introduce you to it now, does not matter.

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MOOC – (Syllabus Template)	
Intended audience	Chemists and Chemical Engineers, Environmental Engineers, Environmental Scientists, Civil Engineers, Pollution Control Administrators.
Is it a core/elective course?	Elective Course
Is it a UG/PG course?	PG Course, (Useful for UG also)
Which degrees would it apply to? (BE/ME/MS/BSc/MSc/PhD etc)	BE/ ME / M.Sc /M.Tec/ MS
Pre-requisites in terms of educational qualification of participants, if any other courses should be done before this can be done	10 +2 + 3 years of BE / BSC Basic knowledge of differential calculus and integration
Industry support – List of companies/industry that will recognize/value this online course	Chemical industries, Pollution Control
The time frame of when you would want to offer the course: Jan-Mar 2016 July-Nov 2015	Jan – June 2018
Will the final certification exam be online or offline?	Online.
Weightage of assignments and final exam score to get certificate score	Assignment 25 Examination 75

So, this course is known as inductively coupled plasma atomic emission spectrometry, if the intended audience are chemists, chemical engineers environmental engineers, environmental scientists, civil engineers and pollution control administrators. You can see that the intended audience covers a number of professionals using, belonging to

different disciplines and regarding more about the course I would like to say it is sort of a elective course you can choose to write an examination in this if you feel like otherwise you can audit the course.

Because the course is so important that it is more important to learn about the subject then wrote it by studying it and then passing an examination of course, it does not mean that it is not meant for students. It is meant for students of MSE chemistry in almost all universities, it is also meant for students of chemical engineering and other as other disciplines which I have enumerated earlier.

Now, lot of people ask me is it a PG course or UG course, I would say it is a PG course, but the conditions in our country are so fluid that within the next 10 years I expect it to be taught in undergraduate course also. So, that brings me to the fourth column, which degree would it apply to, I would say it is the applicable to MSC, M.Tech, MS in engineering, ME in engineering and BE in engineering, By engineering I mean chemical engineering, environmental engineering, civil engineering and pollution control, the environmental pollution control.

Now, what are the pre prerequisites? I want to make it very simple for you, it is basically an understanding of the concept and practice that I want to teach you more than the theoretical aspects. So, I would say 10 plus 2 plus 3 years of BSC or be should be good enough to have the complete understanding of the subjects which I am going to introduce you now.

If you learn this subject, where you expect to use it the application areas are chemical industries and pollution control. So, in addition to the administration and other civil engineers etcetera, etcetera the it is going to be a big asset for almost all of you to learn about the inductive couple plasma atomic emission spectrometry, it is an analytical chemistry, it is an instrumentation, it is also a way of determining the metal atoms in the environment that is what we are going to emphasize.

Now, the timeframe I am planning to give this course in January to June 2018, you can ask your friends to come and join if you like the in this introductory lecture and then it is also finals will there be a certification, the answer is yes, there will be a certification if you wish to choose for certification and take an examination. The examination will be

online with multiple choice questions if you wish to choose it, now what are the weightage of assignments.

The assignment works out to around 25 and examination will be about 75 percent; that means, the total score what you would like to, what you would be attempting these whatever you learn during the course is about 25 percent and in the final examination it will be 75 percent.

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Course Title	INDUCTIVE COUPLE PLASMA ATOMIC EMISSION SPECTROMETRY (ICP - AES) FOR POLLUTION MONITORING					
Discipline	CHEMICAL ENGINEERING					
Number of hours of course 10 hrs/ 20hrs/ 40hrs	10 HRS					

Instructors of the course – Please attach a scanned photograph of each instructor						
S.No	Name of the Instructor	Department	Institute	Mail -Id	Mobile Phone number	Website of instructor
1	DR. J. R. MUDAKAVI (Rtd)	CHEM ENGG	IISc	mudakavijr@gmail.com	09449670938	
Sl.No	Name of TA	Department	Institute	Email id	Mobile phone number	Qualification
	Dr. K. Puttanna	CIMAP, Bangalore	CSIR Lab.	k.puttanna@gmail.com	+918095992052	PhD
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So, the course title for your confirmation once again it is inductive couple plasma, atomic emission spectrometry for pollution control, a pollution monitoring and discipline basic discipline is chemical engineering, but it is also for chemists. Number of hours what I want to teach you in this program is approximately 10 hours that is about 20 hour, 20 sessions of half an hour each.

And let me tell you that it is a very very useful course for almost all postgraduate students of universities as well as technical universities. Now, the instructors of the course I am Dr Mudakavi J R Mudakavi I am from chemical engineering department Indian institute of science. My email address is here Mudakavijr at Gmail dot com, I have I am providing you my mobile number and I am your website instructor also, then I have 2 TA one is dr k Puttanna and who is assisting me in the preparation of slides and other information and another is Chaitra who is my administrator.

So, dr Putttanna is a PhD in chemistry from and worked in CSIR laboratory at Bangalore and then Dr K Putttanna his email address and mobile number contact numbers are all here. So, for any reason if you wish to contact us please do not hesitate to contact us for all the, difficulties if you have or if you have doubts be free feel free to contact me or my assistants will be extremely happy to assist you not only during the course, but also post course I you will still be my students and I will do whatever I can to help you later.

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	Module	Module	Module	Module	Module
Module					
Week 1 (M1+M2)	Introduction to pollution control monitoring (M1-1)	Introduction to pollution control monitoring (M1-2)	Atomic structure 1 (M2-1)	Atomic structure 2 (M2-2)	Atomic structure 3 (M2-3)
Assignment 1*	MCQ				
Week 2 (M2+M3)	Atomic structure 4 (M2-4)	Atomic structure 5 (M2-5)	Interaction of electromagnetic radiation with matter (M3-1)	Interaction of electromagnetic radiation with matter (M3-2)	Interaction of electromagnetic radiation with matter (M3-3)
Assignments 2*	MCQ				
Week 3 (M3+M4)	Interaction of electromagnetic radiation with matter (M3-4)	Interaction of electromagnetic radiation with matter (M3-5)	Interaction of electromagnetic radiation with matter (M3-6)	Theoretical basis of atomic emission spectrophotometry (M3-7)	Instrumentation for ICP-AES (M4-1)
Assignments 3*	MCQ				
Week 4 (M4+M5)	Instrumentation for ICP-AES (M4-2)	Instrumentation for ICP-AES (M4-3)	Instrumentation for ICP-AES (M4-4)	Application of ICP-AES for chemical analysis (M5-1)	Application of ICP-AES for chemical analysis (M5-2)
Assignments 4*	MCQ				

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Now, what is the course program? The course program is like this, that introduction in the week number one, first week there are I have divided it into 5 modules and first module is about introduction to the pollution control monitoring, followed by their there will be about 1 or 2 sessions. Followed by I want you to learn about atomic structure because any spectroscopic technique is based on the atomic structure and transitions taking place at the electronic or nuclear levels these are designated as M 2, module number 2. There are about 3 or 5 lectures in tha, followed by the spectroscopic aspects that is interaction of electromagnetic radiation with matter that is regarding the optics and other related aspects of inductive coupled plasma atomic emission.

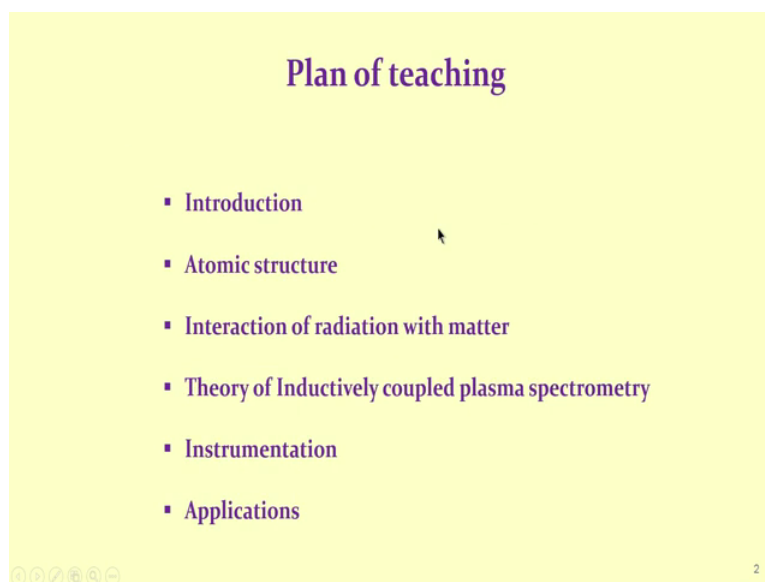
And these are fairly exhaustive about 6 sessions followed by 7 sessions, followed by we by an intensive information program about the ICP AES and that is the core of the material. That will be about 4 units, followed by application of ICP AES to chemical analysis or the determination of the metal ions. Now, why I would like to teach this

because it is a course for you to learn about the determination of the metal ions at parts per million, parts per billion and parts per trillion levels and this is a special course designed for you.

Now, you would if you are taking this course at the end of each week I am going to give you some sort of assignment that is after about 5 hours there will be an assignment as per the program of the this MOOC or NPTEL whatever it is there will be about 3 or 4 assignments followed by an examination. Now, I will leave it to your wisdom to audit the course or to take the course for examination, you can also tell your friends to study about this I have also taught similar courses for spectrophotometry and atomic absorption they are also available in the MOOC or NPTEL programs.

You can look up the available programs in that and you can take up those courses. Now, this is my third course in this program this is inductive couple plasma atomic emission spectrometry. Now, what I would like to do is now is I would like you to go through this slide followed by my plan of teaching.

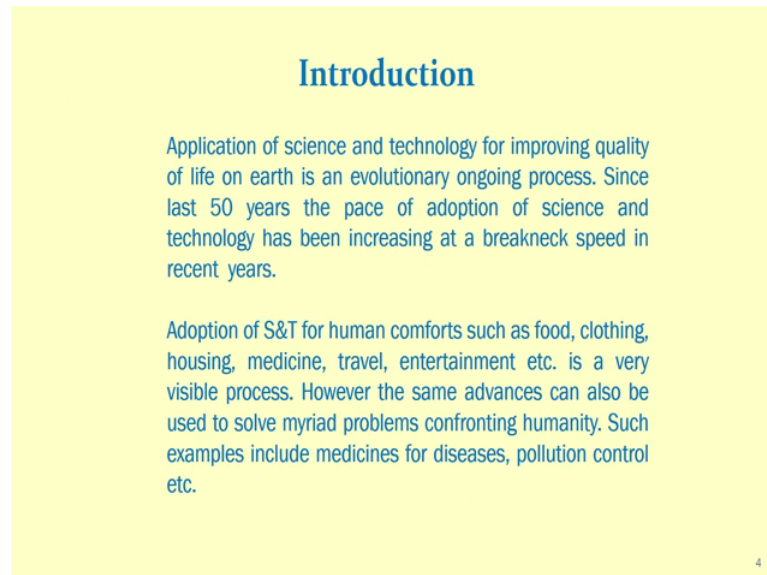
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I have already given you a glimpse of what I am going to teach you and that is the first part is about introduction, second part is about the atomic structure and third part is interaction of radiation with matter, fourth part is theory of inductively coupled plasma mass spectrometry, fourth is instrumentation followed by applications.

Now, this is module 1 I am going to talk to you about the introduction, application of a science and technology.

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Application of science and technology is all about an ongoing process for improving the quality of life on earth. It is an evolutionary ongoing process, since last 50 years the pace of adoption of science and technology has been increasing at a breakneck speed in especially in recent years.

Now, why I would say this because what I am trying to teach you today may become obsolete within the next 3 years or 4 years or 5 years, we may have a different technology. So, that is why what we are saying is we have to be adaptive to changes and advances therefore, the adoption of science and technology for human comforts is very well known, it is available for food, green revolution milk revolution and so many other revolutions for the production of food materials etcetera you must have heard of.

And then it is available for clothing that is the new technologies available for the preparation of synthetic materials in addition to natural materials like wood, bamboo, cloth, cotton etcetera. Terylene, tericot all most of the things and housing there are lot of advances medicine, travel, entertainment list is endless it is a very very visible process. However, the same advances can also be used to solve merit problems confronting our humanity, such examples include poverty elimination and then diseases control, pollution

control and several other problems which are which we are facing at different levels of the current life on our planet.

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Fundamental Sciences such as atomic and molecular structure have made rapid strides in the last century and currently we are able to understand the atomic and molecular structure of elements and compounds in terms of electronic and nuclear structure when they undergo chemical reactions.

Atomic and molecular Spectroscopy is a science which is an offshoot of the structural changes occurring during electronic and nuclear transitions. Over the years spectroscopy has grown into a very powerful tool for the identification and quantification of chemical compounds. The same can also be used to follow the progress of chemical reactions.

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Now, among these fundamental sciences are there such as physics, chemistry, mathematics, such things and among the, among these I am sure you will agree with me that chemistry is the, is one of the most fundamental science and advances in chemistry are always supported by advances in physics and mathematics. It is the chemistry that drives the development of physics and mathematics also quite a lot because chemistry is for us to understand adopt it and then application and theory interpretation and all other things will come later.

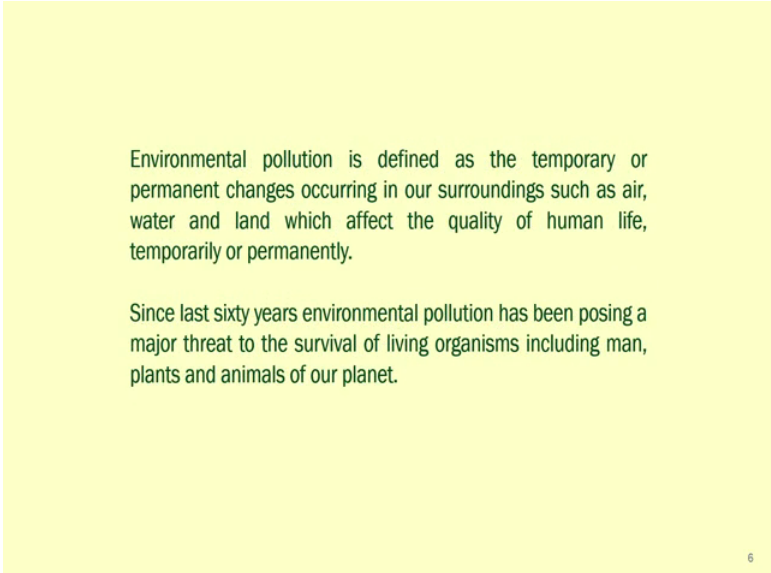
Now, I also wanted you to understand the route of chemistry as we understand today is in the structure of the atoms, you know it is about the elements. All around us wherever we look at, where whatever we are dealing with, whatever we are breathing in, whatever we are using it is all about atoms molecules and chemicals. So, we are able since atomic and molecular structure is a very big part of the chemistry and we have made rapid strides in the last century about regarding the understanding of the atomic and molecular structure. Currently we are able to understand the atomic and molecular structure of the elements and compounds in terms of electronic and nuclear structure when they undergo chemical reactions.

So, among the chemistry we are talking about spectroscopy, why because atomic and molecular spectroscopy is a science which is an offshoot of the structural changes occurring in the atoms and molecules, at what level they occur at electronic level electrons or nuclear transitions. So, over the years spectroscopy has become the backbone of our chemical analysis all because of the rapid advances in instrumentation, electronics, computing technology and presentation crt etcetera, etcetera.

But the basic driving force is the spectroscopy, over the years spectroscopy has grown into a very powerful tool for the identification and quantification of chemical compounds anything you wish to do a chemical analysis you will ask only 2 questions, one is what it is and second is how much it is. So, the goal of all chemical analysis these, how much it is and what it is, sometimes we are also interested in expanding the question of what it is by adding what else it contains.

Again the answer to all these 3 questions comes only from the chemical analysis and a large chunk of it comes from chemical spectroscopy. So, the progress in atomic spectroscopy can also be used to follow the progress of chemical reactions that is one of the advantages as well as one of the important aspects what we wish to cover now.

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Environmental pollution is defined as the temporary or permanent changes occurring in our surroundings such as air, water and land which affect the quality of human life, temporarily or permanently.

Since last sixty years environmental pollution has been posing a major threat to the survival of living organisms including man, plants and animals of our planet.

Now, environmental pollution we have to relate, how do we relate? A chemical process to an environmental process.

The idea is we have to understand apart from chemical spectroscopy spectroscopic techniques, how do we correlate it to the pollution control, environmental pollution control, the idea is we determine the chemicals which affect the environment. Now, what is the environmental pollution, we define it as the temporary or permanent changes occurring in our surroundings such as air, water and land which affect the quality of human life temporarily or permanently. It may be as chemicals by themselves or in combination with other chemicals and bacterial or biological mediators such as virus bacteria and several other n plant and animal life which will interact with the chemicals to alter the fate of the chemicals.

Since last 60 years environmental pollution has been posing a major threat to the survival of living organisms including man, plants and animals of our planet.

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Technically environmental pollution is thought to originate from dust, chemicals and their interactions with microbiological species such as bacteria, viruses, algae, fungi etc. Localized pollution is caused by the,

- (i) Variation of BOD and COD in water bodies by the chemicals and petrochemicals.
- (ii) Atmospheric emissions.
- (iii) Decomposition of organic matter in air, water and land.
- (iv) Irretrievable loss of metal ions and their distribution in the environment.

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Now, technically, what do you say or when do you say an environmental pollution is occurring. Now, you can say that the environmental pollution is thought to originate from dust chemicals and their interactions with microbiological such species such as bacteria viruses algae fungi and so many other the plant and insect products and, but it is localized the pollution that is more dangerous or more visible.

Environmental pollution may occur all over the world. it may occur a particular region, it may occur in the air, in the sky like our ozone hole affecting the whole earth, but whatever happens at the ground level it is the localized pollution that is that catches the

eye. Now, this localized the pollution is basically of about 4 kinds, one is variation of BOD and COD in water bodies, by the chemicals and petrochemicals I hope you all understand what is BOD and COD.

BOD is the biochemical oxygen demand and COD is the chemical oxygen demand; that means, most of the chemicals present in our environment use up the available oxygen in presence of bacteria or without bacteria also the dissolved oxygen to get oxidized to harmless compounds such as carbon dioxide and water. Now, there may be another localized pollution which most of us know are atmospheric emissions, that is the emissions of carbon monoxide, sulfur dioxide, nitrogen oxides and many other gases etcetera which emanate from the human activities or from natural sources also.

Whenever it is human activities will normally attribute it to vehicular pollution sometimes the burning of organic produce in the open air, which we are seeing nowadays almost all over India including Delhi that happened in the recent cricket match, which with lot of ramifications that is particulate matter that is defined as PM₁₀ or PM_{2.5} that is particulate matter of 10 and 2.5 microns that end up in the air which we keep on breathing with deleterious effects on our health.

And the third type of is about decomposition of organic matter in air water and land, this also most of you must be familiar with this type of environmental localized pollution because whenever something is rotting it is all our experience to close our nose and walk around and then if something is rotting in water, we cannot eat it or we cannot drink it, if it is something rotting on the land the produce from the land becomes not usable at all.

Now, there is another kind of pollution, localized pollution that is the irretrievable loss of metals and metal ions and their distribution in the environment. Now, this last one that is irretrievable loss of metal ions and their distribution is another one which is not so visible like all the other 3 which I have described earlier because sometimes the effects are immediately visible, but most of the time if it is metal ions in the environment we are not really affected in a visible fashion, it does not mean that it is not it is a less dangerous also not at all.

Suppose you must have taken breakfast today, if you have taken breakfast you might have taken [FL] and [FL] the [FL] what you eat along with [FL] contains salt, if it contains the salt in a decent fashion in within acceptable limits you will enjoy [FL] and

[FL]. But if the salt is double you may not enjoy it, if it is 3 times you will not enjoy it, but if it is 5 times definitely for your force to eat it you will discard it is toxic it will cause reaction in your stomach.

But if it is some other metal ion apart from salt which is not visible, which is not taste which does not carry any specific taste suppose the concentration is more than 5 times or more than 3 times you will not feel the difference, but it will cause the damage to the same extent, I hope you are able to understand why we are talking about metal ions in particular and what type of pollution it is causing.

Now, this has got direct relationship with the technique what we are going to study that is inductive coupled plasma atomic emission spectrometry.

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While it is true that pollution causes a variety of maladies, it is also possible to at least partially remedy the situation by physically and chemically removing the offending chemicals. Therefore the procedure for environmental pollution control involves:

- Identification and determination of the pollutants and the extent of pollution
- Technical intervention
- Post intervention evaluation

Fortunately it is possible employ atomic and molecular spectroscopy to qualitatively and quantitatively determine the pollutants in any given matrix. The advantages of spectroscopic methods include simple, fast, reliable and cost effective solutions for pollution monitoring.

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Now, while it is true that pollution causes a variety of maladies it is also possible to at least partially remedy the situation by physically and chemically removing the offending chemicals isn't it, it is a very simple process.

Now, animals for example, if they are exposed to a localized pollution of polluted area they can move away to in search of greener pastures which are not polluted, but man is not programmed to move away. If you are a software engineer, if you are in Bangalore, you have to work in Bangalore or whether it air is polluted or not you live there. So, unlike animals localized pollution cannot be a sustainable solution for human beings.

If not for, but it can be a sustainable solution for animals because they do not have the roots on the land. Now, the sometimes it is possible for us to remove the cause of the pollutant pollution by removing the chemicals from the from mixing in the environment, sometimes we move away, sometimes we treat the waste water to get good water, sometimes we treat the waste itself into compost or something like that, that is also another way of accepting. So, we can alter the chemical composition of the environmental pollutants by different techniques.

Therefore the procedure for environmental pollution control what does it involve it involves number one identification and determination of the pollutants and the extent of pollution that is quantitation. Number 2 once you identify the next step is technical intervention, this technical intervention is within our hands it is within our capabilities that is what I have been explaining to you, That is you remove the offending chemical you can compost it and many other you can treat the water land etcetera there is another thing known as a remediation for land soil etcetera that can be done.

And then what is the third way? So, environmental pollution control involves most intervention evaluation. Now, this is a very important aspect of environmental pollution control that is if you do something to remedy the situation occurring due to pollution control the action from your site. You would also like to know what would be the end result by reevaluating that is posting intervention evaluation; fortunately it is possible to employ atomic and molecular spectroscopy to qualitatively and quantitatively determine the pollutants in any given matrix.

Fortunately nowadays we are able to understand our advances in the chemical analysis or analytical sciences have reached such a level that it is possible for us to quickly analyze the cause of the pollution, the advantages of spectroscopic methods include one is they are simple fast reliable and cost effective solutions for pollution monitoring, ok.