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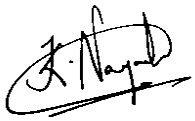
EDITOR'S DESK

Think '**sustainability**' and the words that immediately spring to mind are '**smart**', '**survival**', '**the future**'. Pathways, is now here with its final edition for the year, the souvenir edition of **Chemfluence 2016**, covering a theme that is pertinent to our fast-paced consumer lives: how to be **smart** in order to **survive** in **the future** we create for ourselves. This edition encompasses articles that are in tune with the role chemical engineers play in creating a sustainable world to live in, and we can promise that we'll keep you engrossed with all the intriguing information we have in store.

The academic year 2015-2016 has seen us through some great challenges and opportunities, and we are thankful for each and every one of these, as they have contributed to making us a much more widely recognized and appreciated magazine among students and professionals alike. Pathways has scaled heights we only dreamt of reaching over the past year, and I am proud of the fantastic team of editors that have worked tirelessly to make this achievement a reality. We are grateful for the support we have received from all our readers, in helping us become bigger, brighter and better each day.

We have enjoyed every moment of putting this souvenir together and we hope you'll have as much fun reading it.

HAPPY READING!



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CHEMFLUENCE 2016 SCHEDULE

S.NO	EVENTS	TIME	VENUE
	DAY 2 (19.03.2016)		
1	PAPER PRESENTATION (ENERGY)	9.00 AM-12 NOON	CONFERENCE HALL
2	POSTER PRESENTATION (MATERIAL SCIENCE)	9.00 AM-12 NOON	FLUID MECHANICS LAB
3	EUREKA (ALL ACTIVITIES)	10.00 AM-12.30 PM	ROOM NO 301
4	SPIECHER HAUS	10.30 AM-11.30 AM	ROOM NO 320
5	PAPER PRESENTATION (EFFLUENT)	1.30 PM-4.30 PM	CONFERENCE HALL
6	POSTER PRESENTATION (BIO-ENGINEERING)	1.30 PM-4.30 PM	FLUID MECHANICS LAB
7	GREENOVATE (IDP)	1.30 PM-4.30 PM	ROOM NO 316
8	SHERLOCK MANIA	1.30 PM-2.30 PM	ROOM NO 201
9	MINUTES TO DISASTER	2.30 PM-3.30 PM	ROOM NO 312
10	CHEM CONNEXIONS	3.30 PM-4.30 PM	ROOM NO 312
	DAY 3 (20.03.2016)		
1	PAPER PRESENTATION (MATERIAL SCIENCE)	9.00 AM-12 NOON	CONFERENCE HALL
2	POSTER PRESENTATION (ENERGY)	9.00 AM-12 NOON	FLUID MECHANICS LAB
3	WORKING MODEL	9.00 AM-11.00 AM	ROOM NO 320
4	CHEM QUESTIONNAIRE (ROUND 1 & 2)	10.00 AM-12 NOON	ROOM NO 201
5	PAPER PRESENTATION (BIO-ENGINEERING)	1.30 PM-4.30 PM	CONFERENCE HALL
6	POSTER PRESENTATION (EFFLUENT)	1.30 PM-4.30 PM	FLUID MECHANICS LAB
7	JACK OF ALL TRADES	1.30 PM-3.30 PM	ROOM NO 301
8	CHEM QUESTIONNAIRE (ROUND 3)	1.30 PM-2.30 PM	ROOM NO 201
9	CLICK IT!	2.30 PM-3.30 PM	ROOM NO 312
10	CHEM PICTIONARY	3.30 PM-4.30 PM	ROOM NO 316
S.NO	**WORKSHOP**	**TIME**	**VENUE**
1	MINITAB	1:00 PM-5 PM (18.03.2016)	RAMAN AUDITORIUM
2	MATLAB	9.30 AM-5 PM (19.03.2016)	RAMAN AUDITORIUM
3	ASPEN PLUS	9.30 AM-1.30 PM (20.03.2016)	RAMAN AUDITORIUM
0	SOCIAL ENTREPRENEURSHIP	2PM-5 PM (20.03.2016)	RAMAN AUDITORIUM

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MESSAGE FROM THE DEAN

It is with pleasure to acknowledge that Chemfluence 2016, the 21st edition of the National-Level students' Techno-Management symposium is being organized by the Consortium of Chemical Technologists (CCT), Department Of Chemical Engineering, AC Tech, Anna University.

Chemical engineering has proven to impact diverse industrial sectors and hence the need-of-the-hour is chemical engineers who can contribute to sustainable development that will ensure a better tomorrow, which is the theme that has been aptly chosen for Chemfluence this year.

I trust that the platform being provided by this symposium will serve to broaden the thinking with which we approach solutions to real-world problems. Moreover, it allows students to interact and the questions raised on such an occasion promote a healthy exchange of ideas among students from across the country. In addition to the myriad of events being organized, Chemfluence 2016 is supporting Organ Donation and the members of the CCT have gone to great lengths to raise awareness on its importance.

Hats off to the editorial team on the release of the souvenir edition of PATHWAYS 2016 to commemorate and celebrate this grand event. I would like to also congratulate the student organizers and the staff of the Department of Chemical Engineering for organizing such a successful event year after year. I wish them all success.

DR. S. SIVANESAN

DEAN

A C TECH, ANNA UNIVERSITY

MESSAGE FROM THE HEAD OF DEPARTMENT

Chemfluence has been steadily growing in magnitude over the years. This year focuses on sustainable development, bringing to light the pressing concerns of the dynamic Chemical Engineering industry. This National level Techno-management Symposium brings together students from backgrounds of Chemical Engineering and its allied fields to put together their diverse talents and abilities.

It delights me to find that the Departmental magazine Pathways, with its hardworking and efficient editorial team, provides an excellent platform for the young and creative minds of the Chemical Engineering society to express themselves, thereby giving us all an opportunity to think, innovate and grow. Their themed monthly editions that have been published online, have been welcomed with great response amongst faculty members and students alike.

I firmly believe that the theme chosen this year for Chemfluence'16, is of utmost importance in today's world of rapid consumerism. As Chemical Engineers, it is our duty to redefine the term 'Sustainable Development' and focus our efforts in building what our symposium's tagline aptly describes as "A Better Tomorrow". With this wonderful initiative that the CCT has taken on, I hope this symposium culminates in a grand success that leaves every student with the skills necessary to lead them on the path to a thriving future.

DR. N. BALASUBRAMANIAN

HEAD OF THE DEPARTMENT

DEPARTMENT OF CHEMICAL ENGINEERING

DETECTION OF Cr (VI) IN WATER USING ANALYTICAL IMAGERY

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ABSTRACT

The total content of Chromium in natural waters does not generally exceed 250µg/l. Thus, it is obvious that various forms of Chromium will occur at the levels of tenths or hundredths of µg/l. Its determination requires the application of a sufficiently sensitive method, but its specificity has an important role to play in the case of chemical individuals or selectivity, in regard to speciation of a group of compounds, e.g. valence states or organic chromium complexes. However, there is a lack of specific and selective methods and the concentrations of various forms of the analyte often occur at the level of detection limits of even such sensitive techniques as U-V visible spectroscopy. But the inaccessibility of these lab scale instruments is a big disadvantage for easy detection. This paper provides a new method of analytical possibility of chromium speciation investigation, in natural water samples in a cheap, accessible and efficient manner.

Keywords: Chromium, µg/l, UV spectroscopy, analyte, easy detection

PHYTOREMEDIATION OF DOMESTIC SEWAGE WASTE

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ABSTRACT

Only 26% of total generated wastewater receives treatment and a large part of domestic sewage is not even collected in our country. Dumping of sewage into water bodies bioaccumulates and creates human health hazard that disrupts the aquatic ecosystems. Hence treatment of sewage before being released has become the need of the hour. The techno-economic problems of conventional treatment techniques have lead to the adaptation of new technologies such as phytoremediation. Phytoremediation is a bioremediation process that uses various types of plants to remove, transfer, stabilize and render harmless such environmental contaminants. Besides water quality improvement and energy saving are add-ons in this technique. Our model focuses on treatment of domestic sewage waste using the solar energy driven technique of phytoremediation.

Keywords: phytoremediation, sewage, waste water

ULTRASONIC-ASSISTED ACTIVATED BIOMASS (FISHTAIL Caryota urens SEEDS) FOR THE SEQUESTRATION OD COPPER IONS FROM WASTEWATER

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ABSTRACT

Caryota urens seeds are an agro-based material that can be used as an eco-friendly and low cost adsorbent for the removal of metal ions. In the present study, the biosorption of copper [Cu(II)] ions from aqueous solutions by using raw *C. urens* seeds (RCUS), sulphuric acid modified *C. urens*seeds (SMCUS), and ultrasonic-assisted *C. urens* seeds (UACUS) were investigated. The biosorbent materials were characterized by Fourier transform infrared spectroscopy, X-ray diffraction, and scanning electron microscopy analyses. Batch adsorption studies were performed by varying the operating parameters such as initial metal ion concentration, adsorbent dose, time, temperature, and pH. The optimum conditions for the maximum removal (99.917 %) of Cu(II) ions for an initial Cu(II) ion concentration of 10 mg/L by the UACUS was measured as: pH of 5.0, adsorbent dose of 1 g/L, contact time of 30 min, and temperature of 30 °C. Adsorption mechanism, kinetics, isotherm, and thermodynamic parameters were estimated. A Sips model is fit to explain the Cu(II) ion adsorption onto the RCUS, SMCUS, and UACUS. Pseudo-first-order kinetics agreed with the experimental data and fitted very well. The maximum monolayer biosorption capacity of the RCUS, SMCUS, and UACUS were found to be 5.056, 24.92, and 80.82 mg/g, respectively. The thermodynamic analysis was performed by evaluating the Gibbs free energy ($\Delta G°$), enthalpy ($\Delta H°$), and entropy ($\Delta S°$) of the process. The evaluation showed that the removal of Cu(II) ions onto the UACUS is exothermic and has an impulsive nature of adsorption. A single-stage batch adsorber design was designed using the Sips model to calculate the amount of adsorbent needed to treat the known volume of the contaminated water.

Keywords: Biosorption Fishtail palm *Caryota urens* seeds Ultrasonic Isotherms Kinetics

AN EXPERIMENTAL STUDY ON THE INFLUENCE OF OPERATING PARAMETERS ON THE HEAT TRANSFER CHARACTERISTICS OF AN AUTOMOTIVE RADIATOR WITH NANO FLUIDS

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ABSTRACT

In this research work, the heat transfer with water based Nano fluids was experimentally compared to that of pure water as coolant in an automobile radiator. By varying the amount of Al2O3 Nano particles blended with base fluid water, two different concentrations of Nano fluids 0.25 % and 0.5 % (by vol.) were obtained. These Nano fluids were allowed to flow through the vertical tubes present in the radiator. The flow rate ranges from 0.05 to 0.15 kg/s. The fluid inlet temperature was varying from 35°C to 59°C to find the optimum inlet condition. The increased rate of heat transfer was observed with an increase in volume flow rate, Nano particle concentration. Rate of heat transfer was also found to be increasing with an increase in temperature of hot Nano fluid at the inlet.

FUNCTIONALIZEDPOLSILSESQUIOXANE FILMS FOR ULTRA-LOW ELECTROCHEMICAL DETECTION OF dsDNA

Salunke Ashish Shivaji, Krishnamoorthy Silambarasana, Alam Venugopal Narendra Kumara and James Josepha
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ABSTRACT

Charge transport in polymeric films bound by redox reagents is a topic of current interest. Dynamics of electroinactive ions across the interface is studied by immobilizing ferrocyanide anion in polysilsesquioxanes (PSQs) modified electrode. The present work describes the immobilization of ferro/ferricyanide redox couples in PSQ films possessing protonated amine functional groups by electrostatic interactions. Charge transport in [Fe(CN)6]4- - PSQs film was found to be anion dependent, and its formal potential value vary with relative hydrophilic or hydrophobic nature of anion used in the supporting electrolyte. The [Fe(CN)6]4- bounded PSQs films were extensively characterized by varying different supporting electrolytes anions using cyclic voltammetry. The redox peak currents were linearly proportional to the square root of scan rate implying that the transport of charge carriers is accompanied with redox ions diffusion and electron hopping in a confined space. dsDNA molecules were found interacting with this polymer matrix through anionic phosphate groups. Both voltammetry and A.C impedance spectroscopy studies revealed that these interactions could be exploited for the determination of ultra-low level (0.5 attomolar) of dsDNA present in aqueous solution.

Keywords: polysilsesquioxanes, hydrophilic, hydrophobic, voltammetry, A.C impedance spectroscopy

INDUSTRIAL DEINKING

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ABSTRACT

Paper recycling is supported in developing countries in order to handle the resource and waste management crisis. One of the major steps involved in paper recycling is deinking. Efficient methods of ink removal are perceived to be a difficulty by the Paper Industry in our country. Deinking is the removal of ink from the pulp made out of waste paper. The aim of deinking is reducing the size of the ink particles to the micro level so that it cannot be viewed by the naked eye rendering the recycled paper .The brightness of paper obtained from virgin pulp. The recent technology employed for deinking is multi-aeration cell system which is a floatation mode. The aim of the system is obtain the paper with minimum residual ink and a significant increase in brightness. This depends on deinking efficiency. Optimisation of efficiency is in turn dependent on several psycho-chemical parameters such as surfactant chemistry, hydrodynamics of floatation, design and quality parameters. This poster focuses on improvement of deinking efficiency in the multi-aeration cell by analysing the contributing factors in a laboratory as well as on a large scale. The optimisation of hydrodynamic parameters such as the air-bubble interaction and size of the bubbles were suggested to be implemented during the process of floatation based on the first order kinetics. The quality parameters such as consistency, ash content and brightness were monitored on day to day basis and improved upon by experimental variations and verifications. The results for various improvisations were obtained.

APPLICATION OF MEMBRANE DISTILLATION FOR THE RECOVERY OF AQUEOUS SOLVENT

Aakash Watts and Nihal Rao
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ABSTRACT

In recent years the increasing threat to water quality due to human activities has become a matter of great concern. The water quality has been deteriorated due to exploitation and contamination or a combination of both. RO (Reverse osmosis) is a leading technology for desalination of sea water because of its strong separation capabilities. However, its performance is limited by the formation of polarization film due to high pressure operation which in turn increases the bacterial contamination and fouling process. Membrane Distillation (MD) is a thermally driven separation process which involves simultaneous mass transfer and heat transfer operations through a hydrophobic microporous membrane. The driving force is the vapour pressure difference across the membrane. Membrane Distillation has the potential to become a major contributor for water desalination due to lower power requirements and lower payback period, hence being a very viable technology. Furthermore, this method can also be used for non-aqueous solvent recovery applications. In our paper we discuss the future aspects of membrane distillation with an in house MD unit which is viable, cost efficient and easy to set up. The challenges and advantages of this method for water recovery; significance of specifically tailored membranes and the comparison for different types of Membrane Distillation is also discussed.

CONVERSION OF NON-DEGRADABLE WASTE TO PETROLEUM PRODUCTS

Kaushal Kothari, Neeraj B and Kavya C K
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SRM University, Kattankualthur Campus, Chennai

ABSTRACT

The present rate of economic growth is unsustainable without saving of fossil energy like crude oil, natural gas or coal. Thus mankind has to rely on the alternate/renewable energy sources. On the other hand, suitable waste management strategy is another important aspect of sustainable development. Plastics have been one of the materials with the fastest growth because of their wide range of applications due to versatility and relatively low cost. Since the duration of life of plastic products is relatively small, there is a vast plastics waste stream that reaches each year to the final recipients creating a serious environmental problem. Plastics have now become indispensable materials in the modern world and their application in the industrial field is continually increasing. There is a considerable demand for alternatives to disposal or land filling. Among the alternatives available are source reduction, reuse, recycling, and recovery of the inherent energy value through waste-to-energy incineration and processed fuel applications. Production of fuel from plastics would be a better alternative as the calorific value of the plastics is comparable to that of fuels that is about 46.16 MJ/kg. The properties of the oil derived from waste plastics were analysed and it has properties similar to that of diesel. Waste plastic oil (WPO) was tested as a fuel in a diesel engine and its performance characteristics were analysed and compared with diesel fuel (DF) operation. It is observed that the engine could operate with 100% waste plastic oil and can be used as fuel in diesel engines. Engine fuelled with waste plastic oil exhibits higher thermal efficiency up to 80% of the full load and the exhaust gas temperature was higher at all loads compared to DF operation.

Coffee with the Companies

PATHWAYS has reached out to companies that define the very landscape of the Chemical Engineering industry to get their take on sustainable solutions that chemical engineers must take to hasten our progress to a developed world. Here's what they had to say. *(As told to **Anubhav A Kediaa**)*

More importance must be given to developing oil seeds in the country; the same as that must be given to Cotton and Sugarcane (India was an exporter of these, but has now became an importer). Oil seeds should also similarly be brought into the forefront; this can help in saving a lot of foreign exchange from the imports, money which can be better utilized for further industrial development.

Mr. Aanandh Kumar Kedia
Director, Tamil Naadu Edible Oils Pvt. Ltd.

The pharmaceutical industry relies on innovation and continuous development of novel drugs. With evolving changes in drug regulation, consumer expectations, and competition, the pharmaceutical companies constantly invest in technology and people, and this constant improvement has today led to the sustainable growth of the Indian pharmaceutical market which grows at a rate of over 12%.

Mr. M S Theivendran
Managing Director, Swiss Garnier Life Sciences

CHEMICAL ENGINEERS~ OUR HEROES

Blurring the line between Genius and Insanity

Chemical engineers work in manufacturing, pharmaceuticals, healthcare, design and construction, pulp and paper, petrochemicals, food processing, specialty chemicals, microelectronics, electronic and advanced materials, polymers, business services, biotechnology, and environmental health and safety industries, among others.

The first Chemical Engineer was a German named Johann Rudolf Glauber, who was famous for preparing a concentrated solution of Hydrochloric acid by combining sulphuric acid with table salt. He also concocted an efficient way to produce nitric acid by heating potassium nitrate with concentrated sulphuric acid. In 1880, George E. Davis wrote in a letter to Chemical News "A Chemical Engineer is a person who possesses chemical and mechanical knowledge, and who applies that knowledge to the utilisation, on a manufacturing scale, of chemical action." He proposed the name Society of Chemical Engineers, for what was in fact constituted as the Society of Chemical Industry.

Historically, the chemical engineer has been primarily concerned with process engineering, which can generally be divided into two complementary areas: chemical reaction engineering and separation processes. The modern discipline of chemical engineering encompasses much more than just process engineering. Chemical engineers are now engaged in the development and production of a diverse range of products, as well as in commodity and specialty chemicals. These products include high-performance materials needed for aerospace, automotive, biomedical, electronic, environmental and military applications. Examples include ultra-strong fibers, fabrics, adhesives and composites for vehicles, bio-compatible materials for implants and prosthetics, gels for medical applications, pharmaceuticals, and films with special dielectric, optical or spectroscopic properties for opto-electronic devices. Additionally, chemical engineering is often intertwined with biology and biomedical engineering. Many chemical engineers work on biological projects such as understanding biopolymers (proteins) and mapping the human genome.

-Johann Rudolf Glauber

Chemical engineers face many of the same challenges that other professionals face, and they meet these challenges by applying their technical knowledge, communication and teamwork skills, the most up-to-date practices available, and hard work. Benefits include financial reward, recognition within industry and society, and the gratification that comes from working with the processes of nature to meet the needs of society.

-Ramaiah Kumar, Second Year, Chem Engg

SMART CITIES AND ENERGY MANAGEMENT

-Saru Monica, Final Year, Chem Engg

Across the word, the exodus of people from rural to urban areas is increasing exponentially. By 2050, about 70% of the world population will be living in cities. To accommodate the influx, it will need 500 new cities. The concept of smart cities was born when one of the worst economic crises hit the world in 2009. It all started with IBM in 2008, working on the 'Smart Cities' concept as a part of its 'Smarter Planet' initiative. By the beginning of 2009, the concept had captivated the imagination of various countries. Countries like South Korea, UAE and China were quick to join the bandwagon and started investing heavily in their research and formation.

But what are smart cities exactly?

A 'smart city' is an urban region that is highly advanced in terms of overall infrastructure, sustainable real estate, communications and market viability. It is a city where information technology is the principal infrastructure and basis for providing essential services to residents. Though it may sound futuristic, it is now likely to become a reality in India.

Advances in science and technology have the potential to accelerate these efforts. Local energy management is necessary to achieve a balance between conservation of environment and ease of living. In addition, with reality of global warming and other global environmental problems revealed, energy policies should be driven to reduce our dependency on fossil energy resources by reviewing the electricity expenditure, saving energy in the industry and reducing CO_2 emissions.

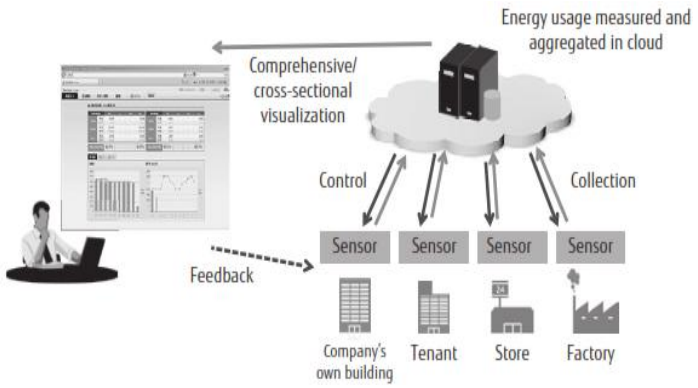
Energy management

In the future, it is likely that companies, which are energy consumers, will need to take greater measures for energy conservation. Advocating energy policies shouldn't stop with the industrial circle. Energy consumption is on the rise in households too. Hence, it is probable that regulations on households and commercial sectors will become even stricter. Energy management is critical to reduce the dependence on fossil fuels and to achieve sustainable growth.

Energy management is the process of monitoring, controlling, and conserving energy in buildings or organizations. It is important to learn how this energy management is done in various countries. Japan sets the bar high when it comes to energy management.

How does Japan do it?

The city is divided into several fields. All the bases (buildings) in a field are virtually connected. The data measured at individual bases are aggregated and stored in a cloud server. The server then visualizes power usage in the form of graphs and tables. The progress is compared with pre-set energy targets. Warnings are also sent to the administrator by periodically monitoring power consumption. Forecasts are done for the energy demand. Excess usage is cut by remote control function. It provides energy saving control on the air conditioners and lighting system.



It is understood that energy management becomes an integral part of smart cities. Much of the importance of energy saving stems from the global need to save energy- this global need affects the energy prices, emissions target and, legislation. The urban revolution is already at work, but only proper planning and innovation in science and engineering will catalyze the process of achieving sustainable and smart cities.

WHAT ARE HUMATES?

Humate materials are substances formed from the biological and chemical breakdown of animal and plant life over a extreme period of time, usually a few million years. Humates are made up of compounds and materials that plant life on earth absolutely needs for growth. Containing a mixture of organic acids, including humic acids, fulvic acids, macromolecules of amino acids, amino sugars, and peptides, the chemistry of humate is so complex it can't really be broken down. It is a complex state of matter structured into fragments of DNA and RNA and so pure it can't even be traced to its origin or specific date

What we do know is that it works extremely well as a base for organic soil conditioners, fertilizer, and plant food tablets. And we know that, not just from the research and applied results from the past 40+ years at Humate Technologies Inc, but from early sustainable agricultural cultures on this continent who knew it worked too. There is evidence that the Anasazi Indians, the Mayans and other early North American Indian cultures applied limestone-gypsum-phosphate rock (where humate materials are found in a natural state) to mineralize the soil. In the 1770's Pennsylvania Amish and Mennonites and German immigrants used humate materials on farm land that had been left depleted by English farmers who moved west to find more fertile soil. The story goes that even early Mormon settlers brought humate with them into Utah to grow crops in the desert. The use of humates to restore the soil and increase plant quality and production is not a new science. But the increased need to re-mineralize, and replenish, our depleted soils is resulting in an increased interest and a return to humate use for sustainable agriculture and growing programs.

HOW DO HUMATES WORK?

We know that this mixture of concentrated nutrients and complex compounds called Humate stimulates growth and plant development, but how does it work? Not a simple answer. Unlike single chemical application for a single result, scientific studies have shown that the beneficial effect of humates involves multiple factors that independently and synergistically work toward a variety of outcomes. Just like trying to breakdown the complex structure of humates, it is equally difficult to single out one attribute for the end result. The elements of the humates combined with the elements of the surrounding environment, with oxygen, with water, all have a synergistic effect to bring about efficient, harmonious and oftentimes immediate results.

WHAT DO HUMATES DO?

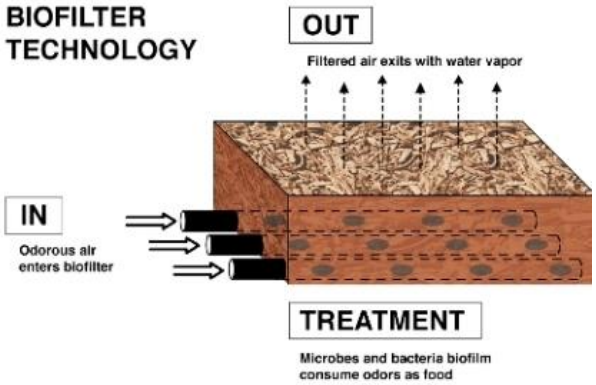
- In the treatment of seeds with humate-water, germination is accelerated, therefore time from seed to sprouts is quicker
- Larger, stronger root systems develop, the immune system is stimulated, endurance increased and resistance to disease and invasive parasites increased
- High ion-exchange which causes an increase in the structural integrity of water, giving it the chemical makeup of melted water, which is known to have a medicinal effect on plants
- Cell wall membrane becomes more permeable, allowing the plant cells to absorb more nutrients, which increases the vitamin and sugar content (this determines the taste) resulting in more nutritious and better tasting produce.

These are only the "tip of the iceberg" of what Humates can do for our soil and plant life. They not only utilize the leftover remains to form but also help minimize wastes and have an unprecedented usage as compared other fertilizers we have.

-Sanjana Ramesh, Third Year, Chem Engg

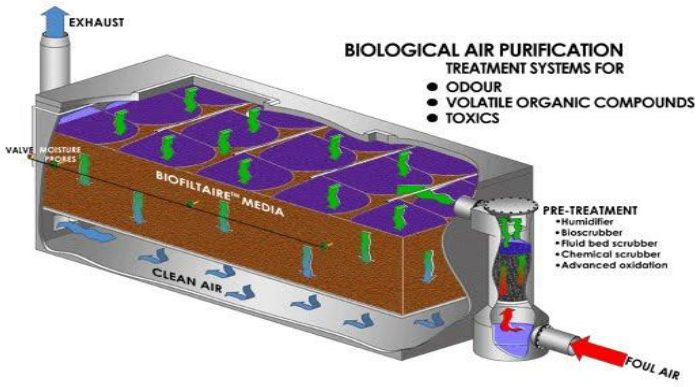
BIOFILTRATION

Biofiltration is a pollution control technique using living material to capture and biologically degrade pollutants. It is the process of passing air or water through a porous, moist material containing microorganisms in order to remove odors and contaminants. The contaminants are degraded to basic compounds like water or carbon dioxide, along with other benign biomass products, all as byproducts of the microbes' metabolic processes. Biofiltration systems are used to treat wastewater and industrial gaseous emissions, as well as emissions from composting operations, among other applications. They have been used since the 1980s for removing noxious odors, but are now seeing widespread use for removal of industrial contaminants as well.



Different strains of bacteria, along with moisture, pH and temperature control, can be used to effectively degrade various target contaminants. Unlike traditional filters, biofilters destroy harmful substances rather than just filtering them out, but they can only work with biodegradable contaminants. Biofiltration is mainly used to destroy toxic emissions like fuel-generated hydrocarbons and certain types of volatile organic compounds (VOCs).

VOCs are created and released during production of a wide variety of products that contain organic chemicals, including paints, cleaning supplies, cosmetics and fuels. They are technically carbon compounds that react with oxygen-containing molecules in the atmosphere when exposed to sunlight, leading to the formation of ozone containing smog.



BIOFILTER:

A biofilter is a bed of media on which microorganisms attach and grow to form a biological layer called biofilm. Biofiltration is thus usually referred to as a fixed–film process.

Generally, the biofilm is formed by a community of different microorganisms (bacteria, fungi, yeast, etc.), macro-organisms (protozoa, worms, insect's larvae, etc.) and extracellular polymeric substances (EPS). The aspect of the biofilm is usually slimy and muddy.

Water to be treated can be applied intermittently or continuously over the media, upflow or downflow. Typically, a biofilter has two or three phases, depending on the feeding strategy (percolating or submerged biofilter):

1. A solid phase (media)

2. A liquid phase (water)

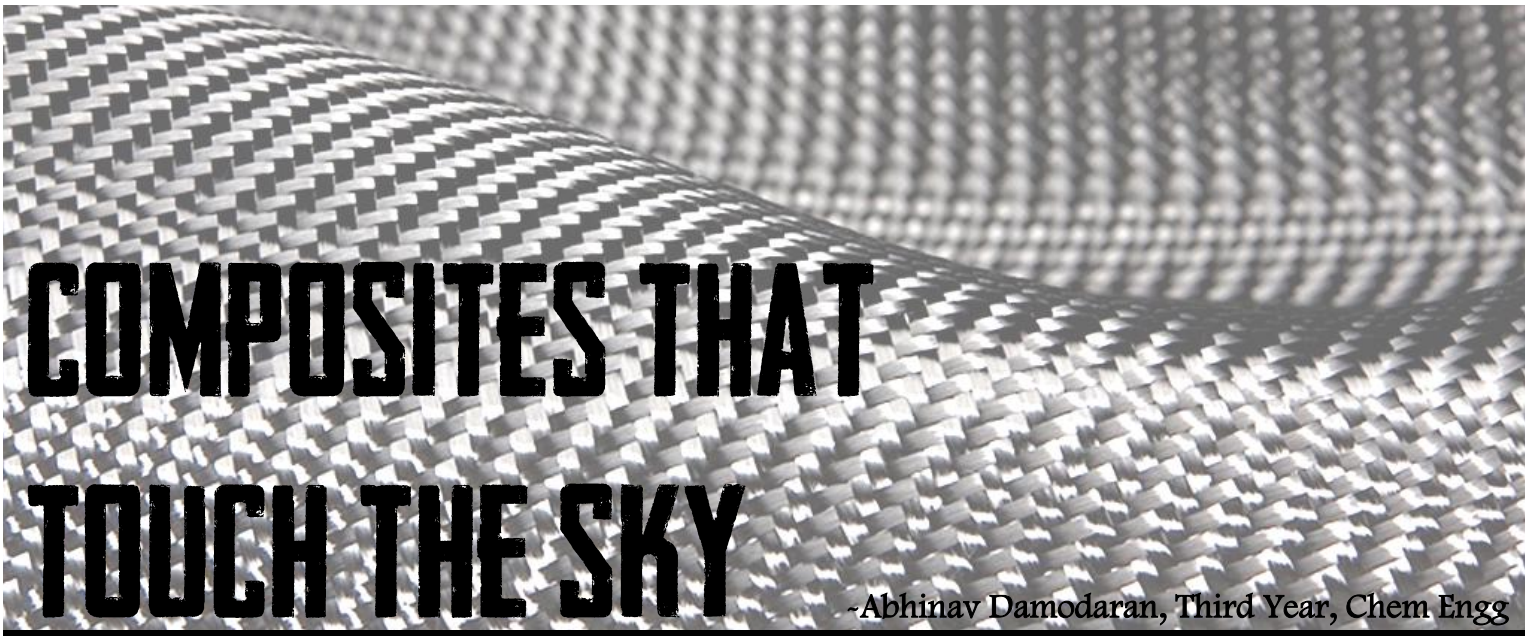
3. A gaseous phase (air)

Unlike traditional filters, Biofilters destroy harmful substances rather than just filtering them out, but they can only work with biodegradable contaminants. Biofiltration is mainly used to destroy toxic emissions like fuel-generated hydrocarbons and certain types of volatile organic compounds (VOCs).

Organic matter and other water components diffuse into the biofilm where the treatment occurs, mostly by biodegradation. Biofiltration processes are usually aerobic, which means that microorganisms require oxygen for their metabolism. Oxygen can be supplied to the biofilm, either concurrently or counter currently with water flow.

Aeration occurs passively by the natural flow of air through the process (three phases biofilter) or by forced air supplied by blowers. Microorganisms' activity is a key-factor of the process performance. The main influencing factors are the water composition, the biofilter hydraulic loading, the type of media, the feeding strategy (percolation or submerged media), the age of the biofilm, temperature, aeration, etc.

- Gokul V , Third Year , Chemical Engg.



COMPOSITES THAT TOUCH THE SKY

~Abhinav Damodaran, Third Year, Chem Engg

The last 50 years have seen advanced composites take off – quite literally, in that many applications of these light but strong materials have been in aviation and aerospace. But modern composite materials have touched just about all industries, including transport, packaging, civil engineering, and sport. They can be found in Formula 1 cars, armor, and wind turbine rotor blades. Leading the charge are carbon fiber reinforced plastics or, more properly, continuous carbon fiber organic-matrix composites.

These materials bond extremely stiff, high-strength carbon fibers into a polymer matrix to give a combined material that is also exceptionally tough and light in weight. The early 1990s saw the development of carbon fibers produced from rayon, polyacrylonitrile, and pitch-based precursors. The long, oriented aromatic molecular chains give the fibers exceptional strength and stiffness. This was a real gain over the amorphous glass fibers used previously in composite materials.

The development of carbon fibers, together with advances in design, modeling, and manufacturing, has given rise to composite materials with controlled, specific properties. **"Rather than an engineer using a constant set of material characteristics, organic-matrix composites and the associated manufacturing methodology now enables the engineer to design the material for a specific application"** says Richard A. Vaia of the Air Force Research Laboratory.

"The manufacturing science has opened up new frontiers, effectively moving component design down to materials design." The spectacular gain in performance has seen the increasing use of these materials despite the cost and increased difficulty in design, shaping, and recycling, such that the new Boeing 787 uses composites extensively in its wings and fuselage.

Carbon-fiber-reinforced polymers (CFRP) are composite materials. In this case the composite consists of two parts: a matrix and some reinforcement. In CFRP the reinforcement is carbon fiber, which provides the strength. The matrix is usually a polymer resin, such as epoxy, to bind the reinforcements together. Because CFRP consists of two distinct elements, the material properties depend on these two elements.

"The reinforcement will give the CFRP its strength and rigidity; measured by stress and elastic modulus respectively." Unlike isotropic materials like steel and aluminum, CFRP has directional strength properties. The properties of CFRP depend on the layouts of the carbon fiber and the proportion of the carbon fibers relative to the polymer. The two different equations governing the net elastic modulus of composite materials using the properties of the carbon fibers and the polymer matrix can also be applied to carbon fiber reinforced plastics.

The Airbus A350 XWB is built of 52% CFRP including wing spars and fuselage components, taking the lead from the Boeing 787 Dreamliner, for the aircraft with the highest weight ratio for CFRP, which was held at 50%.This, along with the Airbus A400M is one of the first commercial aircraft to have the wing spars made from composites, although the A400M isn't the first military aircraft to have structural composite components.

Carbon-fiber-reinforced polymer is used extensively in high-end automobile racing. The high cost of carbon fiber is mitigated by the material's unsurpassed strength-to-weight ratio and low weight is essential for high-performance automobile racing.

Combating Air Pollution in INDIA

Air quality has a strong bearing on India's ability to sustain high economic growth, but national policy has treated the issue with scant importance. This is evident from the meagre data available for a handful of cities generated by the ambient air quality measurement programme. A report from Greenpeace, based on NASA's satellite data, indicates that people living in some parts of India are at greater risk for health problems linked to deteriorating air quality than those living in China.

The measurements for Aerosol Optical Depth, which have been used to assess the level of fine particulate matter (PM2.5) that gets lodged deep in the lungs, point to a worsening of air quality in India in the 10-year period from 2005, particularly for States along the Punjab to West Bengal corridor, compared to China's eastern industrial belt.

High levels of particulate matter in cities arise from construction and demolition activity, burning of coal in thermal plants and from the widespread use of diesel vehicles, among other sources. The Ministry of Environment and Forests has data collected for a six year period that attributes about 23 per cent of particulates to construction activity in six cities studied, and another 20 per cent to diesel vehicles.

Quite simply, pursuing business as usual is not tenable, and the Centre has to act to enforce control mechanisms that will make the air safe to breathe. This has to begin with a more comprehensive system of real-time data collection, expanding the coverage from the present 23 cities to all agglomerations with a significant population and economic activity within a given time frame. Putting the data in the public domain in an open format will enable multiple channels of dissemination; thereby promoting apps created by the community for mobile devices and will in turn build pressure on both policymakers and polluters.

Greater transparency in data dissemination and public awareness hold the key to change. Technological solutions to contain construction dust are equally critical, as is the low-cost solution of covering all urban surfaces with either greenery or paving. Widespread burning of biomass for cooking can be avoided if the government encourages innovation in solar cookers. Cheap, clean-burning stoves can have a dramatic effect as well. The transformation of cities through good public transport and incentives for the use of cycles and electric vehicles — which India is committed to achieve under the Paris Agreement on climate change — will reduce not merely particulate matter but also nitrogen oxide, sulphur dioxide and carbon monoxide. There is little doubt that the deteriorating air quality in Indian cities is already affecting the lives of the very young and the elderly, and reducing labor productivity.

India needs a time-bound action plan

-Arpan Datta, Second Year, Chem Engg

At times, certain amount of the metal being mined ends up in the waste stream. Reprocessing these wastes can result in more usable material.

• **Dust suppression techniques:** During the mining process, large amounts of dust are released into the atmosphere. This can be minimized by pre-wetting the areas to be blasted with high volume sprinklers. Once the dust is in the air, the only way to remove it is through mist cannons.

• **Liquid membrane emulsion technology:** This is a separation technique that can be used to extract usable metal from highly toxic or acidic waste water produced by a mine. This technology can even deal with dilute solutions

• **Sulphuric acid leaching extraction process:** Currently, Bastnaesite is generally processed in a hydrochloric acid leaching process. This process leaves fluorine and thorium contaminated wastes and it creates cerium of low purity. A sulphuric acid leaching extraction process can produce high purity cerium while also allowing thorium to be separated for use and better containment

• **Impermeable tailings storage:** Tailings are often stored in some form of tailings pond. Radioactive elements in this pond can pollute the water and if leaks occur, the surrounding area. Tailings will be required to be stored in impermeable tailing ponds. These ponds become impermeable by adding a layer to the boundaries that does not let liquid through. Alternatively, the tailings can be dehydrated into a paste

• **Choice of ventilation and diesel engines:** 10 percent of mining costs come from electricity consumption. Better ventilation systems and diesel engines could be purchased by mines to maximize efficiency.

-Lakshna V, Second Year, Chem Engg

Chemical engineers are involved in the following activities of mining:

1. High-value refinery trouble-shooting
2. Process engineering and design
3. Production supervision and management
4. Technical supervision
5. Project engineering and management
6. Research and development
7. Technical contracting
8. Environmental impact assessment and its management

TECHNOLOGY	OLD METHOD	GREEN MINING METHOD
Power Use and Emissions	Large amounts of grid power are necessary. Equipment used high-emission fuels like diesel and propane	The mining site will have its own heat and power plant running on natural gas
Water Use/ Waste Water production	Huge amounts of freshwater had to be pumped to the site for use. Up to 850 gallons of waste water would be produced per minute which then had to be pumped miles away to evaporation ponds	Almost the entire initial freshwater brought in to start the process can be recycled. More than 120 acres of evaporation ponds will be eliminated and freshwater consumption will be reduced by about 90%
Tailings	Mine tailings needed to be stored behind a tailings dam along with the wastewater	Water will be removed and recycled from the tailings to create a paste. The paste will be layered and impact on the environment will be reduced
Air Emissions	Harmful Chemicals had been emitted into the atmosphere from previous methods	The harmful chemicals are still produced but now there are flue gas treatment plants to minimize CO_2 and other chemical emissions

"BIOMODD"

The Art of Sustainable Science

- Priyadarshini Jinmayam, Third Year, Chem Engg

Biomodd is a multifaceted socially engaged art installation that finds meaningful relationships between biology, computers and people. On the most basic level, Biomodd creates symbiotic relationships between plants and computers, and ignites conversations among the community around them.

For example, algae are used to cool computer processors so they can run faster, while the heat that is generated by the computer electronics is used to create ideal growing conditions for a plant-based ecosystem.

- Relationship between plants and computers
- Energy produced by modern technology to create growing conditions for a plant-based ecosystem
- Requirements are minimal

- Biologist-artist Senior TED Fellow Angelo Vermeulen
- First version started in Athens, Ohio in 2007
- Maximum utilization of unwanted production of energy

Belgian biologist-turned-artist and Senior TED Fellow Angelo Vermeulen and fellow collaborators have brought Biomodd to a number of different countries throughout the world. The first version started in Athens, Ohio in 2007, and has since traveled to the Philippines, Slovenia, New Zealand, Belgium, the Netherlands, New York, Germany, Kosovo, and now London.

The idea of Biomodd is an efficient way of sustaining energy. In the present scenario it is really wise to have sustainable forms of effective energy and conserve the environment. Biomodd is a fully-packed process wherein the simple form of energy produced by modern technology is used to sustain life. The requirements of a fully functional Biomodd are minimal, thus it is a convenient form to produce energy and also provide life to green plants and micro organisms in exchange.

If in a couple of years Biomodds are successfully installed in various sectors, a lot of energy can be produced and conserved at the same time. It is not only eco friendly but supports plant life with maximum utilization of unwanted production of energy. Biomodd is a game changing innovation that is bringing about a viable change to the idea of energy and energy conservation. A large scale establishment of Biomodds will have a great impact on us and our environment.

Sustainable Farming:

Small steps to a big tomorrow!

Sustainable farming or sustainable agriculture is using farming practices considering the ecological cycles. It is also sensitive towards the microorganisms and their equations with the environment at large. In simpler terms, sustainable farming is farming ecologically by promoting methods and practices that are economically viable, environmentally sound and protect public health. It does not only concentrate on the economic aspect of farming, but also on the use of non-renewable factors in the process thoughtfully and effectively. This contributes to the growth of nutritious and healthy food as well as brings up the standard of living of the farmer.

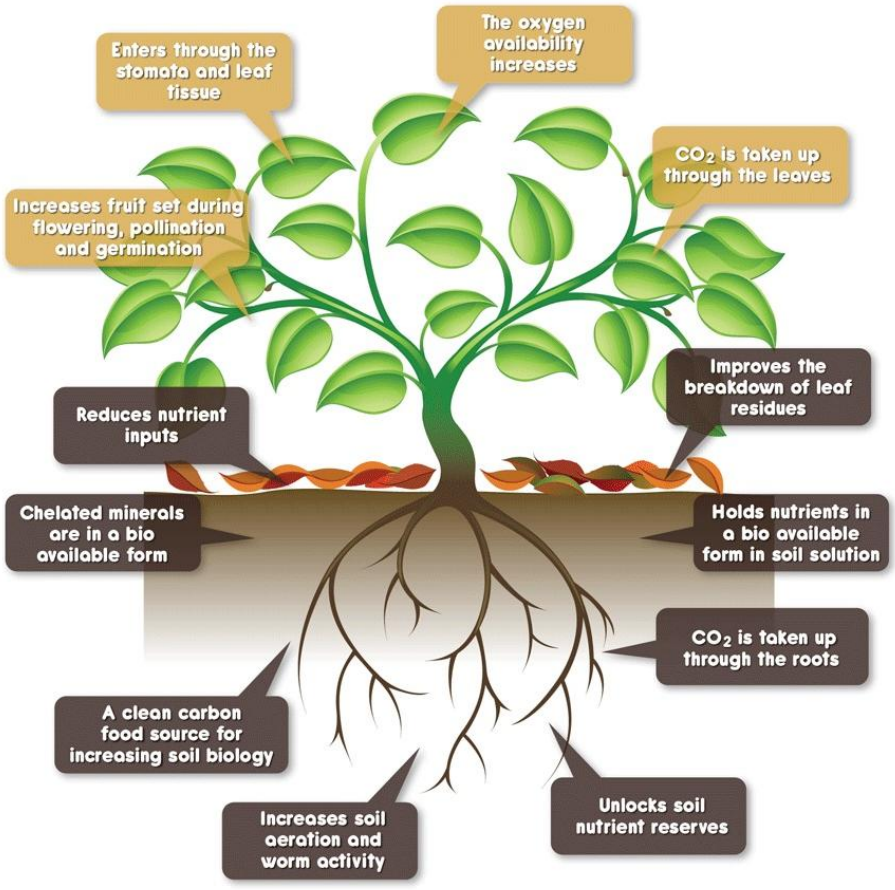
Our environment, and subsequently our ecology have become an area of concern for us over the last few decades. This has increasingly led us to contemplate, innovate and employ alternate methods or smaller initiatives to save our ecology. One such initiative is sustainable farming. It simply means production of food, plants and animal products using farming techniques that prove to be beneficial for public health and promote economic profitability. It draws and learns from organic farming.

Having understood what organic farming is, a lot of new ways have been tried, some fruitful while others perished with no concrete results.

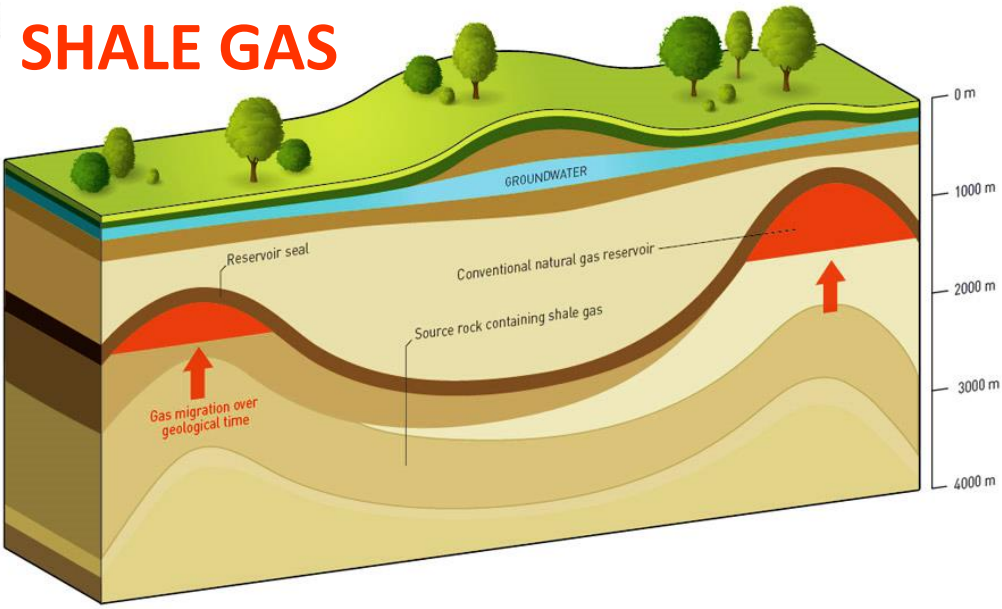
- **Humates**
- **Microbial Processing**
- **Liquid Fertilizers**
- **Micronised mineral suspensions**

In a gist, the above are all techniques used to make products that will satisfy the need of today without causing much harm for a better tomorrow. Also they are made to use raw materials that are not scarce so are not exorbitantly prized.

The most desirable among these are the humates. They are said to have been used for a very long period and work really well.



SHALE GAS



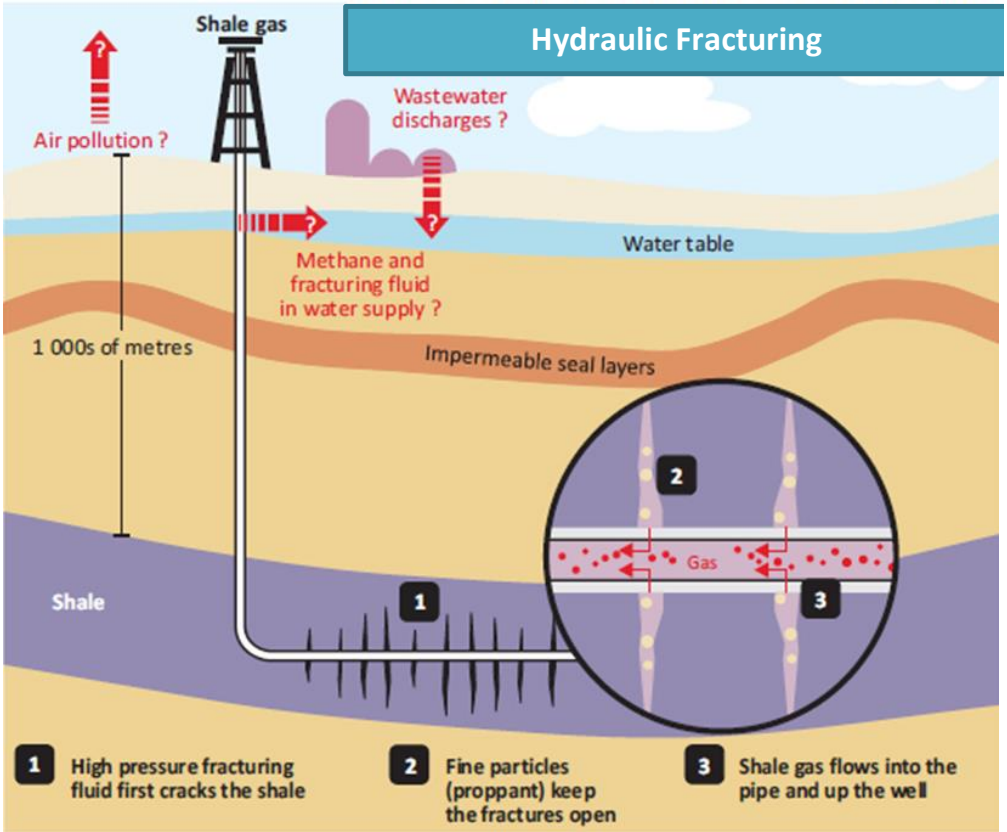
Shale gas is a type of natural gas trapped in shale formations. It is a highly efficient source of energy compared to coal and petroleum based energy sources both in terms of efficiency as well as reducing pollution levels. In western countries like United States, shale gas is already being used extensively. According to recent estimates, it has been found that vast reserves of shale gas are present in China and India.

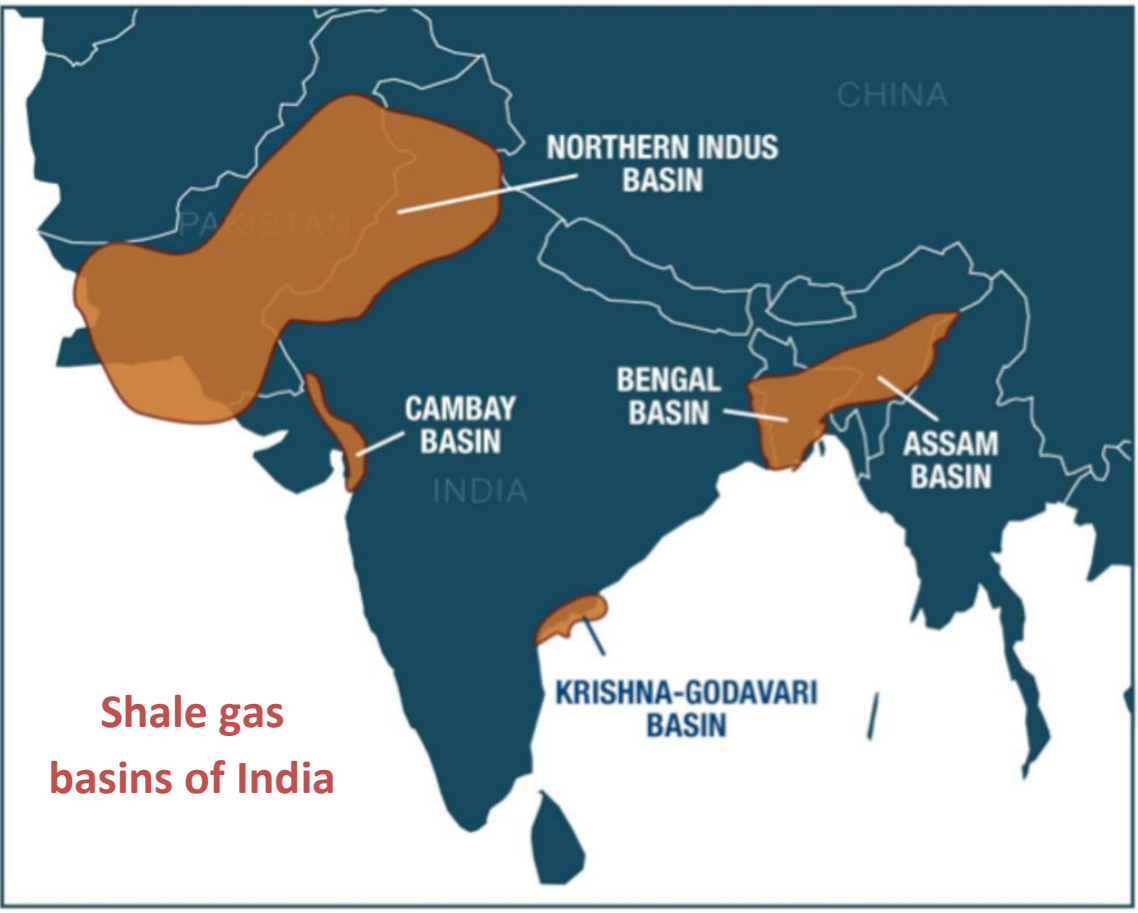
According to industry estimates, India is believed to have about 63 trillion cubic feet of recoverable shale gas reserves which is more than 20 times the size of the country's largest gas deposit KG-D6 block (leased by Reliance Industries) in the Krishna-Godavari basin off the eastern coast.

So in a country like India which is in desperate need of clean energy, why is shale gas still not used?

India is hoping to unlock its widespread shale gas reserves, mostly located in terrain that is difficult to reach, by inviting investments from private companies. The reserve India has is enough to run the country's gas-fired power stations for at least 20 years at current consumption rates according to industry analysts. But experts say it may take years for the country to access and realize profits from the valuable natural resource because of lack of infrastructure, opposition to raising gas prices and paucity of information about exactly where to find the gas. Minister of Petroleum Mr. Veerappa Moily and his top aides have repeatedly promised that the government is on the verge of finalizing a policy on shale gas exploration, but slow assessment of the size and accessibility of actual reserves and how to price the gas have hindered progress towards developing a roadmap for shale gas extraction.

Shale gas is trapped deep underground between rocky formations and is hard to extract. But recent technological advances have made it possible to extract. Oil companies inject chemically-treated water at high pressure into the ground that helps release the gas from underground, a process known as hydraulic fracturing or fracking. The process is criticized by environmentalists who argue that fracking can cause water pollution since chemically-treated water is used to bring out the gas. They say it may be difficult to dispose of the treated water. However, industry officials say that the treated water can be re-used for further fracking and need not be disposed of at all.





In conventional oil and gas fields, India usually asks private companies to share a part of their profits from the resources, once they have recovered the cost of exploitation. But this system has become unsatisfactory in the eyes of ministers who believe private companies often exaggerate their cost estimates, petroleum ministry officials say. Now the petroleum ministry wants to switch to a production-sharing mechanism for all gas projects including shale gas, whereby private operators share a percentage of their revenue with the government from day one. Private operators say that they have no problem with this, so long as they get a free hand in gas pricing.

This is where things begin to come unstuck, according to industry watchers. A panel of government appointed experts, convened by the prime minister, in January proposed doubling gas prices from their current fixed rates. The proposal met with fierce opposition from end-user industries, such as power generators and fertilizer mills, who benefit from low fuel prices. The end-users argue that fuel price rises increase their production costs, and because of government controls on the price of their products, they aren't allowed to raise their prices in proportion thereby suffering huge losses.

The government's interest in developing shale gas reserves has been kindled by success in extracting the gas in the US. The extraction of domestic shale gas deposits will be critical to India's aim of zero energy imports by 2030. The country currently imports 75% of its energy requirements. But even if contracts are simplified and gas prices are freed from government control, there are other obstacles standing in the way of extraction. India's gas reserves belong to the government rather than private landowners as in the U.S. so private operators must obtain government contracts to begin exploration instead of dealing directly with a landlord.

India also needs to map out the reserves accurately. Preliminary findings show that they are spread out predominantly over eastern and western parts of the country mainly in the western state of Gujarat and eastern states including West Bengal. There are also some isolated deposits in central India. Experts say the bulk of the reserves in eastern India lack the necessary network of pipelines to transport the gas–a task that many private operators are wary of undertaking.

The country has in the last two years gone from being import-dependent to having a gas surplus after the discovery of vast reserves of oil and gas deep below ground in rocky, shale formations

-Arpan Datta, Second Year, Chem Engg

10 WAYS CHEMICAL ENGINEERS CAN SAVE THE WORLD FROM CLIMATE CHANGE

-Nayantara K, Final Year, Chem Engg

Systems-thinking

Chemical engineering makes its contribution by understanding how whole systems work, and generating engineered system solutions to meet desired targets. The ideology and discussion behind climate change solutions is in place, but it needs a chemical engineering to apply technical solutions

Energy efficiency

Becoming more energy efficient is the obvious easy win (at least for chemical engineers). The chemicals sector is the most energy intensive industry, but current internal rates of return stand at just 12-19%. Chemical engineers can change this and make energy efficiency the number one priority.

Renewables

The low carbon energy system can only work if the way we generate and consume energy changes. This means applying renewable energy technologies, such as wind and solar. Chemical engineers are working on ways of producing low-cost renewable energy sources, like spray on solar cells.

Carbon capture, storage and utilization

If we intend to continue using fossil fuels, we need to decarbonise electricity production; and carbon capture and storage (CCS) is a readily deployable technology solution to do this. Chemical engineers are also working on technologies to turn captured carbon into useful products, such as plastic bottles, face cream and wood glue.

Nuclear Power

Nuclear power's capacity to provide base-load power makes it a stable and low-carbon energy supply, because nuclear doesn't emit carbon dioxide during power generation. Chemical engineers not only work to design new reactors, but they also ensure standards of safety, efficiency and environmental performance are met.

Sustainable bioenergy

Carbon emissions could be prevented by using sustainable bioenergy. But raw materials used in bioenergy production – food crops like maize and sugarcane – come with a lot of challenges. Chemical engineers have the technology to use these materials efficiently and make bioenergy production cost effective.

Unconventional gas

Using unconventional gas like shale gas or coal seam gas is a more environmentally friendly option than existing fossil fuels. Switching can result in around 50% less carbon dioxide emissions. Chemical engineers work to ensure that extraction of unconventional gases is performed to the highest environmental standards.

Energy storage and grid management

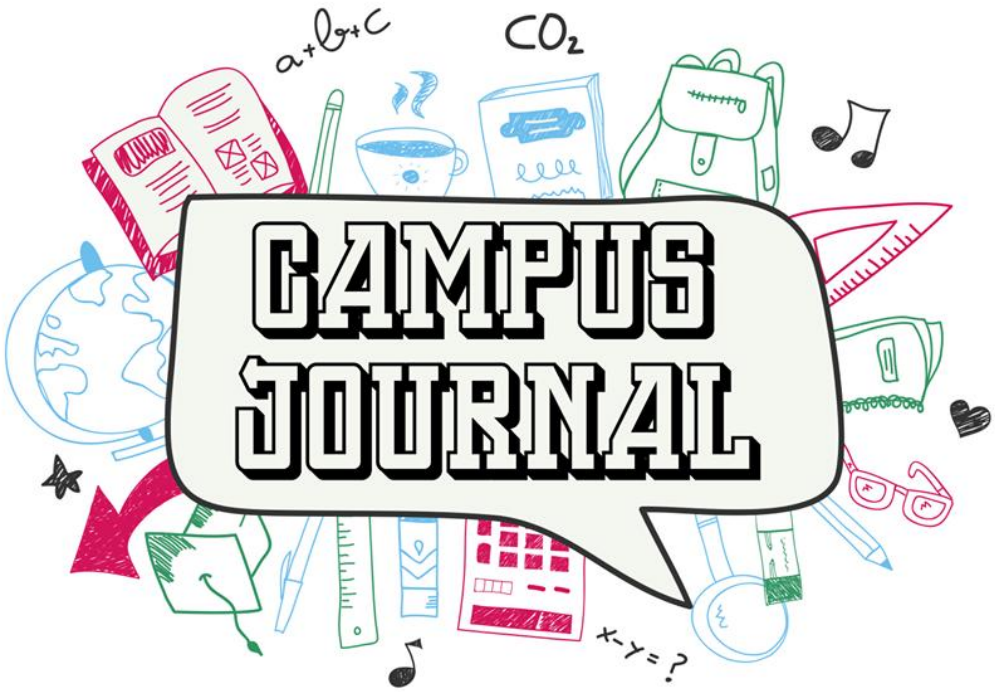
Ideas including using embodied energy in chemicals as stored energy – to be released on demand via chemical conversions. Effective energy storage is a major part of the climate change solution.

Sustainable food

The agriculture sector emits 24 per cent of global GHG emissions, and chemical engineers are helping to cut these by making food production more efficient, for example by making fertiliser in a low-energy way or by reusing food waste.

Water-energy-food Nexus

Chemical engineers play a major role in delivering sustainable solutions at the water-energy-food Nexus. We should not think of water, energy and food as separate entities; Nexus-thinking should play a part in all our climate change solutions.



CONNECTING READERS **Since August 2015**

After a brief hibernation, Campus Diaries is back to entertain the readers. In the previous editions of Campus Diaries, we had a small tour taking readers in and around the campus and some interesting information that crossed our paths. To summarize the experience, the final edition has been chosen in such a way that, even first time readers will have a complete experience of the entire journey through this section of the magazine. **There are a lot of interesting things to do in our excellent college and Campus Diaries has tired its best to cover almost everything:**

1. Visit the canteen and have the ever refreshing Sambhar Rice!! (Food is a good beginning)
2. Spend your evenings with your best friend on the green benches of the Textile road.
3. Celebrate your friends' birthdays in the Parking lot.
4. Gain some last minute wisdom before exams in the Wi-Fi hut. (It really helps a lot)
5. Visit SAP campus once and admire their talents.
6. Take a selfie with the Alagappa Chettiyar Statue.
7. Make the Security Guard ask you to show him your ID Card.
8. Come to college only to attend a function in Raman Auditorium
9. Accompany your class representative to the Class Committee meeting. (Expect the Unexpected)
10. Socialize with your seniors in the CCT room.
11. Get to know the Cabins of all the staff members.
12. Visit the Department Library.
13. Experience the Beauty of Room#201.
14. Sit in any of the classrooms just to get kicked out by a group of students who appear suddenly for their regular class.
15. Attend at least one class in Room#301.
16. Go to the terrace and have a breath taking view of the college and the city.
17. Attend a class in the CBT building.
18. Play with the fish in the Ground floor of the CBT building.
19. Visit the Crystal Growth Centre.
20. Attend a workshop in the Briefing hall.

21. Try anything at the Aavin Milk Parlor.
22. Have a nice lunch in the Fluid Mechanics Lab on the occasions of Guest lectures.
23. Experience the regret of not being ragged.
24. Visit the Textile Quadrangle.
25. Play Badminton in the A C Tech Quadrangle.
26. See the friend and the child inside every faculty member during Aurora.
27. Exhibit your talent and enjoy other talents during Kalakrithi.
28. Visit the Grand Triple Helix Auditorium inside CLRI.
29. Visit the Parade Ground.
30. Experience the Grandeur of A C Tech Hostels.
31. Kotturpuram Parking lot - connecting people more than the Textile road.
32. Walk across the ground to return books in the Main Library.
33. Return to A C Tech from the Library through Madras University and see the Mini Jungle inside the campus.
34. Withdraw money from any of the ATMs while leaving to your hometown.
35. Stand in the queue to pay the exam fee at State bank.
36. Visit Gurunath and chill with your friends.
37. Be in the A C Tech Main building during Republic Day and Independence Day.
38. See a movie with your friends in the Main Gallery.
39. Befriend all the dogs around the campus.
40. Experience Chemfluence which will be different every year.

Most of the people would have done all the above 40 things, but the next 10 are for people who are adventurous with exceptional exploration skills.

41. Visit the Highway laboratory of the Civil Engineering Department.
42. Come to Anna University from the Anna Gem Science Park School.
43. Visit the Abandoned Power Station in CEG.
44. Experience the Night life in Anna University – Stay Awake the whole night roaming around the campus.
45. Name all the blocks of CEG Boys Hostel.
46. Find the Knowledge Data Centre.
47. Have snacks at the Aavin Parlor of DOTE campus.
48. Explore the underground laboratory of A C Tech.
49. Visit the Transcript Section.
50. Enter Anna University through Kotturpuram and come out near Raj Bhavan.

Apart from all the fun that A C Tech gives you, the life experience gained is unparalleled. Right from the freshman year to the final year, life at A C Tech is packed with surprises and experiences. Enter the college campus as a teenager and leave the campus as an adult. You will get an excellent opportunity to explore different aspects, ideas and fields, test your knowledge and improve your expertise. Thus, it shapes your career to very great extent, moulds your thoughts and changes your vision towards problems.

"With this edition, I am signing off from Pathways. I have an emotional bond with PATHWAYS. Not just me, but everyone on the team has a connection with the magazine that cannot be explained. It is very hard to think that this will be my last article as a team member. I forever owe PATHWAYS and my team a great debt, for bringing out the talent in me and for making me the person who I am today."

- Sriram R, Final Year, Chem Engg

Waste Management of a Sustainable City

Chemical engineers will play a major role in waste management of a sustainable city, which widely focuses on 3R's: Recycling-be it metal cans of Aluminium or waste paper or plastic; Reusing-of waste materials through energy recovery techniques has also proved very revolutionary in extracting optimum resource from waste; Reduction of waste.

RECYCLE

Chemical engineers have played a key role in building the post-consumer and industrial waste recycling industry. Any successful recycling program must have three basic qualities:

1. A suitable collection infrastructure

2. Appropriate reprocessing techniques to convert the waste into suitable end products

3. A need or a market for the recycled products.

Recycling aluminum

Recycling aluminum, however, is more challenging. The process for recycling aluminum was developed by chemical engineers in the 1960s, and aluminum is now one of the most widely recycled materials. The widespread use of recycled aluminum saves energy and reduces pollution, because mining and processing raw bauxite ore to extract the aluminum it contains is very energy and waste intensive.

Recycling paper

As paper mills cannot use recycled paper as a direct substitute for virgin tree pulp, chemical engineers have devised and optimized processes that involve blending recycled paper and water to produce a pulp slurry, removing all inks and other performance chemicals in the paper, and filtering the slurry to remove solid impurities. One of the biggest technical hurdles chemical engineers had to overcome was the fact that recycled pulp has shorter fibers than virgin pulp. This characteristic makes the finished paper weaker and less attractive. By combining virgin pulp (typically from wood chips) with recycled pulp, chemical engineers solved the problem with a processing technique that produces newsprint and other recycled-paper products that meet all strength and aesthetic requirements.

Recycling plastics

Plastics are used in so many aspects of our daily lives, so they represent an ever-growing part of the nation's waste stream. We can now recycle most plastics into useful products. Because of chemical-engineering innovations, plastics are separated by machine and reprocessed without significant material breakdown, enabling reuse of many such plastic products as pipe, toys, and decorations. This process not only protects our environment from plastic litter but also helps the city become more energy independent.

REUSE

Energy recovery from waste is the most efficient way to reduce waste. Sustainable techniques such as pyrolysis were introduced.

Pyrolysis

Pyrolysis is the thermochemical decomposition of organic material at temperatures between 400°C and 900°C without the presence of oxygen or other reagents. The pyrolytic breakdown of wood produces a large number of chemical substances. Some of these chemicals can be used as substitutes for conventional fuels. The distribution of the products varies with the chemical composition of the biomass and the operating condition.

It leads to the formation of bio-oil, biochar (it can be used to increase the soil organic contents of eroded areas. Adding these materials may make a longer term impact on the soil productivity) and other gaseous products which provides us with an alternate avenues to rely on.

REDUCE

An important method of waste management is the prevention of waste material being created, also known as waste reduction. Methods of avoidance include reuse of second-hand products, repairing broken items instead of buying new ones, designing products to be refillable or reusable, encouraging consumers to avoid using disposable products, removing any food or liquid remains from cans and packaging, and designing products that use less material.

Sustainable waste management is not a soul responsibility of a chemical engineer but each citizen can contribute in multiple ways to make our society better.

-Neel Barge, Second Year, Chem Engg

WHY PETROLEUM?

Petroleum has superior energy density compared to other commercially available fuels, and it is part of a mature and low-cost distribution system with applications across most vehicle types. Oil is expected to continue to dominate the fuel market for years, but it will cede share to alternatives.

Petroleum causes a wide array of sustainability impacts, including a large share of global greenhouse gas (GHG) and other emissions from transportation. It has also been associated with wider environmental and human rights impacts during drilling and refining, and occasional but destructive toxic releases from spills and accidents.

Market Outlook

Oil is a fungible global commodity, making it rare among fuels in being traded as essentially the same product worldwide. Petroleum demand remains strong, though it is beginning to cede share to alternatives for several reasons, including rising public concern and regulation of high-carbon energy sources; reduced potential for producing fuel from inexpensive, conventional supplies; and the increasing viability of alternative technologies.

The price of oil has a strong, albeit complex, impact on the competitiveness of alternative fuels. Low oil prices curtail short- and medium-term investments and returns on alternatives like natural gas, but are unlikely to be sustained in the long term. The rise of carbon regulation and the increased costs associated with developing unconventional petroleum sources point toward a long-term trend of higher oil prices, while costs fall for alternatives.

Vehicle Applications

Diesel derived from petroleum generally works with any diesel internal-combustion engine (ICE) vehicles. It performs well in virtually all conditions, is ubiquitous and dependably high quality, and works with virtually all engines that are designed to use it. Therefore, it is the baseline fuel of choice for most medium- and heavy-duty applications.

KEY ISSUES

Key Feedstock and Process Choices

Diesel is produced through a series of activities that start with drilling or mining (generically called "production"), followed by processing through fractional distillation in refineries (there are about 130 in the United States) before being distributed locally via pipelines or trucks (and barge or rail to a lesser extent) to terminals near regions of demand.

There are over 150 standard regional blends of oil ("benchmarks"), which can be themselves blended together before or at a refinery to create the end fuel.

Conventional

Conventional production by drilling produces oil with natural pressure during "primary recovery," after which pressure is induced by water, steam, or chemicals in "secondary" and "tertiary" recovery. New "unconventional" sources include: oil sands and other extra heavy oil, oil found in ultra-deep water formations and in the far North, and oil produced using high volume, horizontal fracturing ("fracking").

Unconventional

One of the most important of these for fuel users is fracking, where fissures are created in rocks by pumping high-pressure fluids down a wellbore to stimulate flow. Fluid known as "produced water," returns to the surface with recoverable quantities of oil in addition to brines, metals, and injected chemicals.

Another is oil from oil sands: oil that was mined (generally open-pit) and separated from the clay, sand, and water in which it is found and "upgraded" to produce a refineable product.

KEY UNCERTAINTIES AND UNRESOLVED ISSUES

Uncertainty: Climate Change (Unconventional)

Generally speaking, oil sands and heavy oil have greater processing requirements than conventional oil, which leads to additional GHG emissions.

Uncertainty: Water Availability (Unconventional)

Largely a consideration for unconventional production methods, energy growth is projected to increase freshwater withdrawals from 85-165 percent by 2025.

Drilling operations create "produced water," which may contain arsenic, cadmium, mercury, and lead. Additionally, fracking for oil and upgrading oil sands uses more water than conventional systems, including some alternatives such as some biodiesels.

Uncertainty: Arctic and Ultra Deep Ecosystems (Unconventional)

Exploration is growing rapidly in the Arctic as melting sea ice makes coasts and waterways more accessible. In addition to the environmental and social vulnerability of the region, its remote location makes mitigation and cleanup operations difficult. There is also concern about the heritage and symbolism of keeping this area pristine. The current and potential impact on ecosystems is not well understood.

KEY IMPACTS

Impact: Climate Change

Transportation fuel creates around 25 percent of global GHG emissions, and oil represents over 90 percent of that share. Total annual emissions from petroleum are projected to grow from 11.1 GtCO2e in 2011 to 12.5 GtCO2e in 2035, due principally to increased transport demand.

Furthermore, studies show up to 80 percent difference in upstream GHG emissions from different types of oil, with "extra-heavy," "high steam," and "high flare" oils producing significantly higher emissions.

Impact: Air Pollutants

Transportation-related emissions are estimated to be responsible for about half of deaths from outdoor air pollution, which is now the biggest environmental cause of premature death, resulting in an estimated 110,292 deaths in the Unites States in 2010.

These impacts are largely the result of tailpipe emissions that include suspended particulate matter, nitrogen dioxide, benzene, and other pollutants.

Impact: Human Health

Prolonged worker exposure to diesel exhaust from drilling, completion, trucks, and equipment such as pumps can result in chronic health effects. Refining also contributes to air pollution that includes criteria air pollutants, volatile organic compounds, and hazardous air pollutants.

Impact: Biodiversity

Open pit mining, tailings ponds, and groundwater contamination can pose serious threats to fresh water and marine environments. Depending on timing and location, a spill can cause significant harm to individual organisms and entire ecosystems.

The frequency and volume of oil spills have declined in almost every year since 1973, primarily due to reduction in spills from barges and tankers.

SUSTAINABILITY POTENTIAL

Best Case

Lowest emissions from diesel are associated with relatively light blends with the least energy-intense methods of conventional production. For petroleum to be sustainable long term, solutions would need to be found to remove or capture carbon. Zero-emissions controls can eliminate air pollution during vehicle operation. Applying best practices for drilling and mining drastically reduces potential water, human health, and ecosystem impacts from production.

Best Practices

- **Apply Fleet Efficiency and Emissions Control**

Since the introduction of catalytic converters and improved fuels to enable them in the mid-1970s, there have been significant reductions in tailpipe emissions. Risks to human health from diesel exhaust in North America have been drastically reduced as a result. New telematics enable fleet efficiency, while numerous innovations in vehicle design have increased fuel economy, and built-in technologies help capture tailpipe emissions.

- **Minimize GHG Emissions from Production, Refining, and Distribution**

Promote production and distribution practices that reduce methane emissions leaks from natural gas (such as widespread adoption of "SMART" leak detection and repair), reduce venting and flaring, expand use of CO2-enhanced oil recovery, and minimize emissions during refining. Applying these across unconventional production sites will significantly reduce their sustainability impacts.

- **Reduce Wider Community Impacts of Production**

Many petroleum producers are in a position to proactively improve impacts. However, because of the large environmental and security externalities involved, markets alone are not equipped for comprehensive response, and government policies will be needed to create a transportation fuel system that makes use of oil more sustainably.

Widespread adoption of environmental and social management systems, especially in unconventional production, will greatly improve practices. Ensure "produced water" is treated or injected into confined aquifers.

- **Apply Standards in Unconventional Petroleum Production**

Adopt best practice environmental standards for "tight oil and gas," especially around water and chemical management and transparency. Improve production impacts of oil sands and heavy oil, which includes (1) water reduction and the use of dry tailings (for mining) and (2) greater energy and water efficiency. Improve oil sands footprint management by making seismic lines and road access more benign.

- **Avoid and Effectively Prepare for and Manage Spills and Accidents**

Improve emergency preparation and response for production in extreme environments, such as (1) the Arctic and other far north regions and (2) deepwater, subsea response, and capping/containment.

- **Promote a Culture of Accident Prevention**

Improve environmental health and safety in operations, including increasing safety of sour oil and gas production and oil and gas refining, reducing toxic releases and pipeline and shipping spills, and investment in training and education. Towards this end, integrate lessons learned around enabling a corporate culture to prevent accidents, and apply the lessons to the context of the Arctic and deepwater.

-Namratha Munish, Third Year, Chem Engg

MIRACLE WORKERS

"When life gives you lemons, make lemonade." That's for ordinary people.

"When life gives you lemons, make miracles." That's for us, Chemical Engineers.

It is no mere statement that Chemical Engineers are Universal Engineers. After 4 years of engineering life, it is no easy task to feel enthusiastic about being a Chemical Engineer. It feels like we have a pretty narrow career ahead with not much scope, when compared to those of the humungous computer science or IT departments. But to turn the frowns upside down, we should probably look up and check out how important we are in the global scenario.

There are a few questions that are most commonly asked in a community of sad depressed engineers who feel their future is bleak. And what better way to answer them than from someone who's been there, done that, and overcome it?

What can a Chemical Engineer do?

The question should probably be rephrased as "What can't a chemical engineer do?"

A degree in chemical engineering will open up a wide range of employment avenues for you. You could go into manufacturing, pharmaceuticals, health care, pulp and paper, design and construction, petrochemicals, food processing, polymers, biotechnology, environmental health and safety, energy, electronics, nanotechnology, advanced materials and many other fields.

CHEMICAL PROCESS INDUSTRIES (CPI):

Designing and operating reactors, processes, and systems to combine, transport, separate, and recycle chemicals. Examples of CPIs are agricultural chemicals, catalysts, specialty chemicals, paints/varnishes/lacquers/paper coatings, pigments and inks, petrochemicals, plastics/synthetic resins/composites, polymers, pulp and paper, rubber, soaps/detergents/perfumes, synthetic fibers, textiles and coatings.

BIOTECHNOLOGY:

Using living cells, cell materials and biological techniques to produce antibiotics, insulin, recombinant DNA, artificial organs, techniques for medical, environmental and nutritional improvements, among other things.

FOOD AND DRUGS:

Chemical engineers deal with the processing, preparation, packaging and preservation of food, beverages and pharmaceuticals. This industry needs Chemical Engineers to design new products to meet consumer demand and improve performance and quality.

ADVANCED MATERIALS:

Chemical Engineers are employed in the Aerospace, Automotive, Electronics, Minerals and Imaging sectors to design and control production of advanced polymers, ceramics and hybrid materials for improved performance.

ENVIRONMENT, HEALTH AND SAFETY:

Every process involving chemicals produces some by-products, and Chemical Engineers control these variables through process monitoring and control, efficient and safe process design, waste treatment, environmental impact studies, and so on.

FUEL AND ENERGY:

They are involved in the production and refining of petroleum and petrochemical products, as well as nuclear and synthetic fuels. Chemical Engineers are also instrumental in developing alternate energy sources.

ELECTRONICS:

Chemical Engineers are involved in materials development and production, process control equipment and algorithm design, in the manufacture of microchips and integrated circuit, and in producing components that efficiently dissipate heat and electromagnetic signals.

GOVERNMENT, BUSINESS, LAW:

Chemical Engineers can use their technical training to join government agencies, business, patent law, insurance, industrial finance, and publishing. Some U.S. Government employers are the Department of Energy, the Environmental Protection Agency, the U.S. Navy, NASA, the Department of Agriculture, and the Patent and Trademark Office.

PROCESS DESIGN AND CONSTRUCTION:

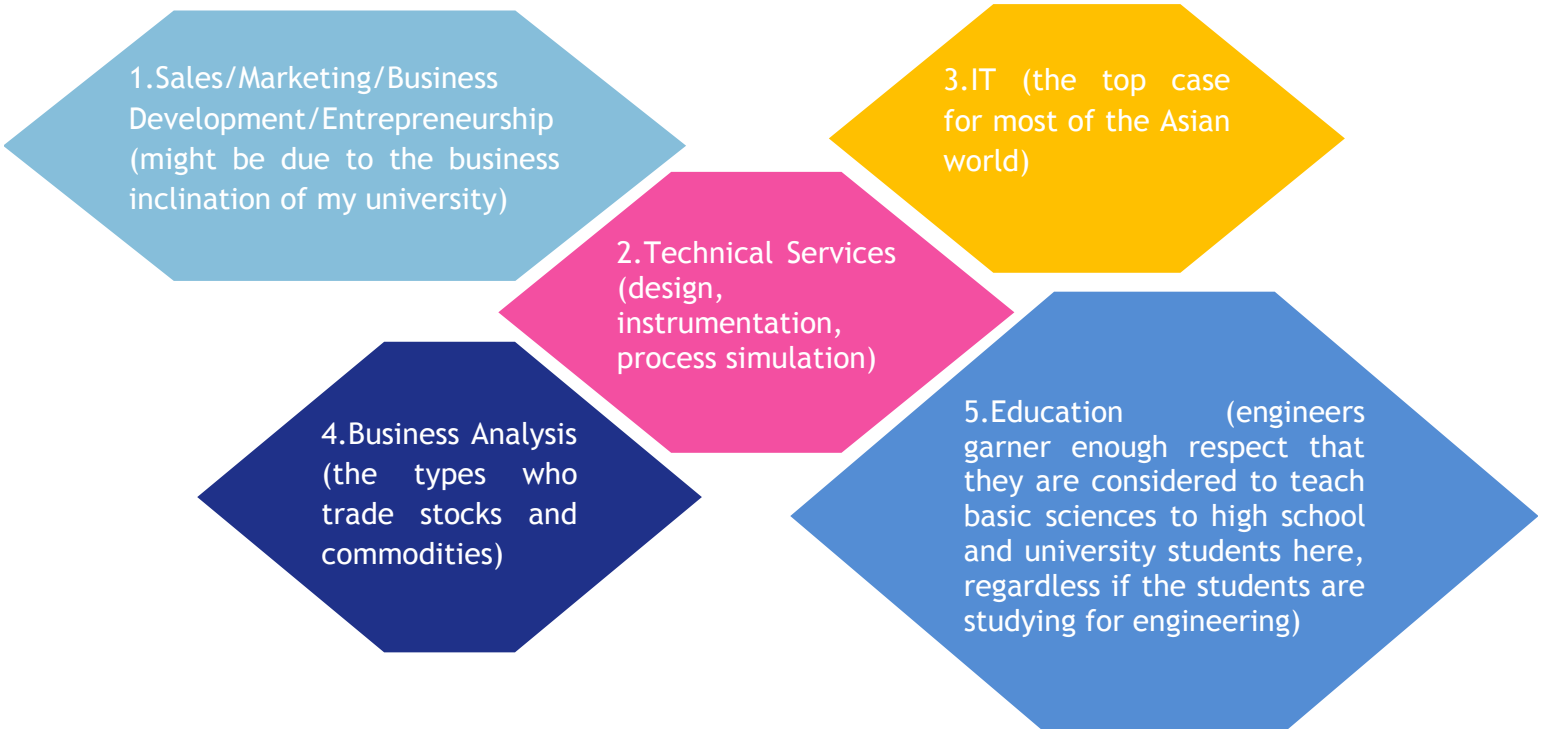
Chemical Engineers help in the building of facilities and specialty operations, and they design and troubleshoot processes to make sure the chemical operations are safe and efficient.

- Pranjali Tripathi
Ph.D in Chemical Engineering

Can Chemical Engineers get good jobs in fields other than chemicals, like technology?

The answer heavily depends on how broad your background is, and for engineers just starting out, most of it is from what they did in university.

I work for the oil and gas industry, but engineers from my graduating class have succeeded establishing careers in the following:



And then there's some who have made tangential career moves after university. One classmate of mine makes iPhone apps for a living now, while another is a leader in her church. These classmates of mine took what they have learned in engineering school (abstract reasoning and communications, respectively) and ran away with them.

- Xavier Fernandez
Energy Engineer

I work for an aerospace company that designs, builds, and launches rockets. My bachelors was in chemical engineering and after I graduated I worked as a process engineer in polymers for a year and then for biotechnology for 3 years. I fit in well at my current company because processes are processes and much of the design philosophy, skills, and understanding I gained as a process engineer were useful for aerospace.

- Doug Duchon
5 years of Consulting and Chemical Process Engineering

Fun fact:

Intel hires more Chemical engineers than Electrical or Electronics engineers!

In summary, chemical engineers have a versatile enough background to command respect in a wide range of industries outside the chemical process industries.

So worry no more, and stride ahead! Life's going to take you through a long way of opportunities before you tire yourself!

Chin up! Eyes open! Good Luck!

-Bhuvana Jagan, Final Year, Chem Engg

WHAT'S NEW?

REUSE THE MINING WATER! –Chemical engineers at the University of Florida are developing a device to separate the particles from the waste used in mining, potentially in a matter of hours rather than decades and saving billions of gallons of water. The tank consists of electrical charge, when the clay or solid filled water passes through the tank, the clay gets separated due to the charge and the water becomes reusable. The project is still in process of scaling it to the industrial level usage.

HOW CAN THE BRAIN HANDLE SO MUCH DATA? –Humans can categorize data using less than 1 percent of the original information, and validated an algorithm to explain human learning - a method that also can be used for machine learning, data analysis and computer vision. Researchers Georgia Tech's College of Computing studied human performance in "random projection" tests to understand how well humans learn an object. They presented test subjects with original, abstract images and then asked whether they could correctly identify that same image when randomly shown just a small portion of it. Next, researchers tested a computational algorithm to allow machines (very simple neural networks) to complete the same tests. Machines performed as well as humans, which provide a new understanding of how humans learn. Results were recently published in the journal *Neural Computation* (MIT press). It is believed to be the first study of "random projection," the core component of the researchers' theory, with human subjects. Although researchers cannot definitively claim that the human brain actually engages in random projection, the results support the notion that random projection is a plausible explanation, the authors conclude. In addition, it suggests a very useful technique for machine learning: large data is a formidable challenge today, and random projection is one way to make data manageable without losing essential content, at least for basic tasks such as categorization and decision making.

SWITCHABLE POLYMER COULD COMBAT ANTIBIOTIC RESISTANCE – The polymers are actively antimicrobial only when they need to be so they don't continually pressure bacteria to evolve resistance. These biocides are cationic polymers derived from poly (phenylene vinylene). The polymers have linear backbones with cationic ammonium arms that control the material's antibiotic properties. The positively charged arms help kill bacteria by penetrating into cell membranes. This behaviour is governed primarily by electrostatics, although hydrophobic interactions may also contribute. The polymers are designed to attack bacterial cells and not mammalian cells, including healthy human cells. To switch off the antimicrobial activity, the team exposes the polymers to ring-shaped cucurbit[7]uril molecules, or CB[7]. These compounds cuff the ammonium arms, hindering the polymer's ability to latch on to bacteria. To restore the polymer's antimicrobial activity, the team adds the small molecule amantadine to the bacterial system, usually a culture of *E. coli*. Amantadine bonds with CB[7], removing the cuffs from the polymer

Gokul V, Third Year, Chem Engg

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