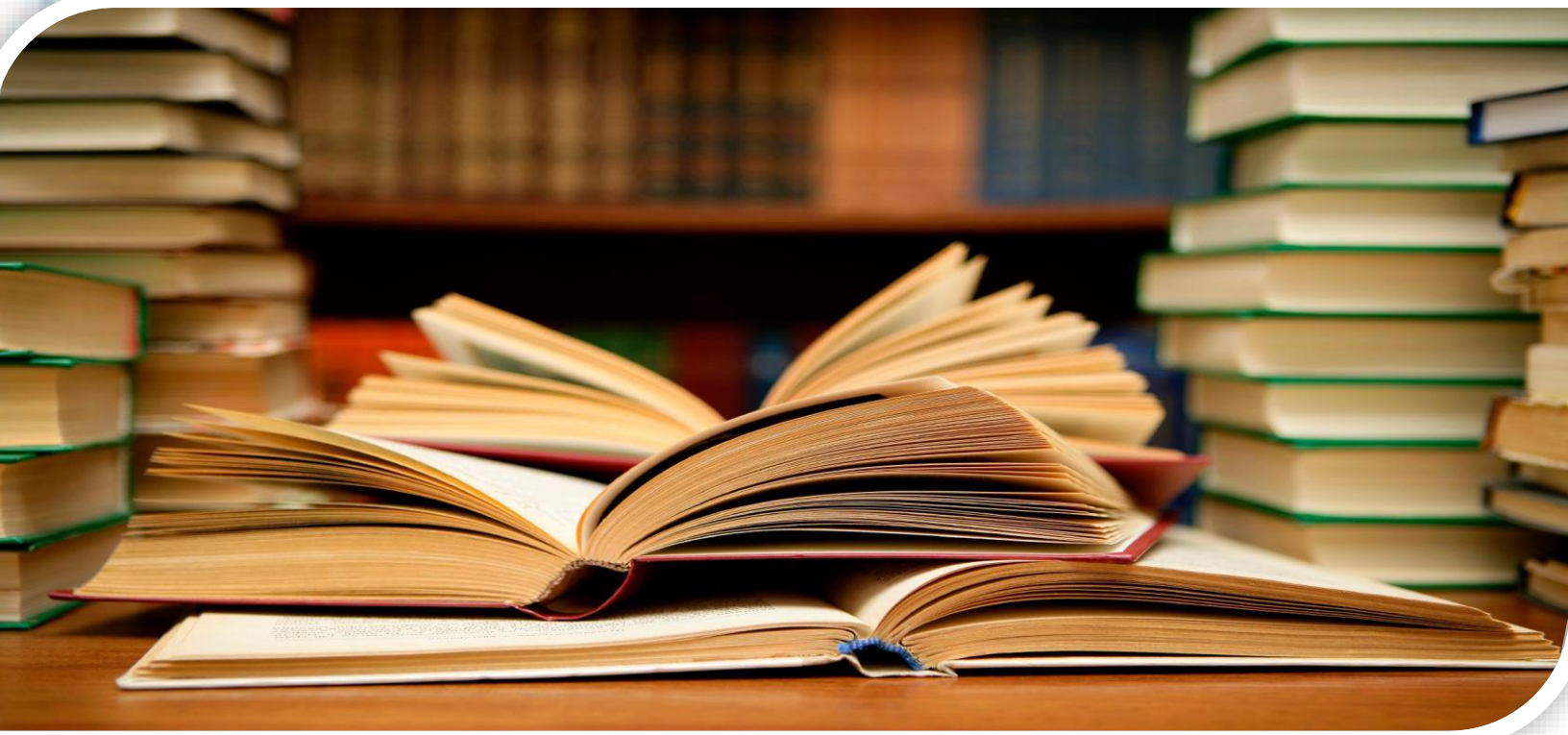
"Integration of Research to Industrial Application"



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FOREWORD

The massive demand for complementary training of engineering graduates in India indicates a mismatch between academic education and industry requirements. This project identifies the gap between academia and industry and provides a platform to bridge the gap using the concept of Learning Factories.

The document is a compilation of research abstracts of students pursuing B.E., M.E., Ph. D. in the field of Chemical and Environment. The objective behind publishing this book is to strengthen the skills of students as well as to motivate students towards research and development activities in the field CP/CT. This also focuses on practical implementation of this research based activities into industries to promote Sustainable Industrial Development in the State of Gujarat.

GCPC has invited abstracts of dissertation/ thesis/ research paper from gradate, post graduate and Ph.D chemical and environmental student from different engineering and environment science colleges of the state and received total of 99 abstracts. These complied abstracts will be distributed to the industries; so industries can implement the work done by the student where it is feasible. With this, GCPC makes an effort to fill the gap between the industries and academia.

We are confident that this effort will go a long way in inspiring the younger generation of entrepreneur technology and academia decision makers.

We are thankful to our panel of experts: Dr. Ravji Patolia, Proprietor, M/s. Parth Chem & Technologies, Vatva; Mr. Alok Kumar, Chief Executive Officer, Narmada Clean Tech Ltd.; Mr. M.A. Hania, President, Dahej Industries Association and Senior Vice President of

M/s. Meghmani Ltd. Dahej; Mr. Amit Dhruv, CEO, Ester India, Nandesari; Mr. Sanjiv Vaijanapurkar, Deputy Environment Engineer, GPCB; and Mr. Paresh Mevawala, Director, Enpro Envirotech and Engineers Pvt. Ltd., Surat for selecting the best five abstracts.

We are thankful to Dharmsinh Desai University-Nadiad, Om Engineering College-Rajkot, Pandit Deendayal Petroleum University-Gandhinagar, Shroff S.R. Rotary Institute of Chemical Technology-Ankleshwar, Maharaja Sayajirao University-Baroda, Silver Oak College of Engineering and Technology-Ahmedabad, Shri SadVidya Mandal Institute of Technology-Bharuch, Pacific School of Engineering, Marwadi College-Rajkot, Nirma University-Ahmedabad, Vishwakarma Government Engineering College-Ahmedabad, L.D. College of Engineering-Ahmedabad, GEC-Bharuch, SAL Institute of Technology & Engineering Research-Ahmedabad, L.E. College-Morbi, V.V.P. Engineering College- Rajkot for their continuous support in sending abstract of dissertation of their students. All students deserve the Best Wishes for their future.

Dr. Bharat Jain
Member Secretary
Gujarat Cleaner Production Centre

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ABSTRACT TITLE

PhD (Chemical Engineering)

1. Integration of Nano size TiO_2 assisted Photo-catalytic Oxidation and Adsorption Process for Pharmaceutical Effluent Treatment

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In this research integration of advanced oxidation treatment using TiO_2 nano particles and Hydrogen Peroxide followed by activated charcoal adsorption was studied. TiO_2nano particles were prepared using sol-gel technique and analyzed using X-Ray Diffraction (XRD). The physicochemical characteristic of the filtered industrial effluent was determined. The Total Organic Carbon (TOC), Total Dissolved Solids (TDS) and pH was 3110 mg/L, 14000 mg/L and 8.71 respectively. pH was found to decrease during photo-catalytic oxidation process from 7.5 to 6.4 due to decrease in hydroxyl ion concentration during photo-catalytic oxidation. In first treatment Photo-catalytic oxidation followed by adsorption process was studied. TOC and TDS removal achieved in these treatments was 73.63 % and 42.85% respectively in 6 hr time period. In second treatment integration of Photo-catalytic oxidation with addition of Hydrogen Peroxide (H_2O_2) followed by adsorption process was studied. TOC removal achieved in these treatments was 97.96 % in same time period of 6 hr. which shows that addition of H_2O_2 has enhanced treatment efficiency. Further with addition of H_2O_2has increased hydroxyl radicals resulted in increase in TOC removal efficiency from 73.63 % to 97.96 %.

PhD (Environmental Science)

1. Microbial extracellular polymeric substances mediated synthesis of nano-particles and its potential application for bioremediation.

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Green synthesis of nano particles using biological systems, plant products and microorganisms are potentially considerable because of its non-toxic and environmental friendly nature. In the biosynthesis of nano Particles, functional groups of EPS act as capping and stabilizing agents. The Cdsnps enriched EPS have enhanced adsorption capacity of Heavy metals, which may be due to increased adsorptive sites. The current study demonstrates, an efficient biosynthesis method to prepare NPS using EPS extracted from a bacteria and its comparison with chemical method using D-glucose. The synthesized NPS were characterized by Ultraviolet–visible spectroscopy, ATR-FTIR spectrometry, X-ray diffraction, Field emission scanning electron microscopy and Transmission electron microscopy. Atomic absorption spectroscope (AAS) was used to study adsorption capacity of pristine EPS, functionalized EPS and NPS incorporated functionalized EPS. The percentage removal of Heavy metal also increased by using nano particle incorporated functionalized EPS, which provided a greater surface area for Metal adsorption. Therefore, this work suggests that EPS fictionalization is a feasible approach for nano particles synthesis and removal of Heavy metal from aqueous solution.

2. Emerging innovative cleaner technology for remediation of pollution from industrial wastewater: A Potential Application of nanotechnology for abatement of pollutants.

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Commercialization, Industrialization and ever increasing population are amongst the main reasons for increase in amount of wastewater. Several methods are being used to ensure a continued supply of water for the indispensable purposes. In the area of water purification, nanotechnology provides for the possibility of a proficient removal of pollutants, viruses and microorganisms etc. Nanotechnology is also being considered as a method to provide an economical, convenient and eco-friendly way of wastewater treatment. The synthesized samples presented a pure metallic phase with nano metric particle size. The photo catalytic abatement of dyes (Methylene blue, Malachite Green, Rhoda mine B, Methyl orange) nutrients (Sulphate, phosphate, Nitrate), heavy metals(lead, arsenic and chromium)and degradation of PAHs- Pyrene & Phenanthrene from synthetic and industrial effluents was elucidated in aqueous suspension containing nano particles under UV irradiation. Moreover, these selected nano particles were entrapped in sodium alginate beads and used for removal of pollutants from industrial wastewater in glass reactor based *Ex situ* studies. The experimental result showed that synthesized nano particles are of <50 nm, shows efficiency to degrade pollutants up to 80- 98% and *Ex situ* study revealed steady removal and reuse of entrapped nano particles beads up to 3 cycles to provide cost effective technology.

PhD (Environmental Engineering)

1. Scope of Resource Conservation Technology for Effective Resource Management

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Over the past three decades or so, internationally, rapid strides have been made to evolve and spread resource conservation technologies like zero and reduced tillage systems, which enhance conservation of water and nutrients, reduce the cost of operation, fuel consumption, energy requirement and time for operation of various crops.

Experiment was conducted to compare tractive, root profile and crop parameters *viz.*, tractive, fuel and power delivery efficiencies, energy requirement, soil cone index, soil moisture content, soil bulk density, weed growth, germination, root length, plant height, seed weight, yield *etc.* among resource conservation machineries and conventional practice under leveled and unleveled plots.

Experiment was carried out for three consecutive years from *kharif*-2012 to *kharif*-2014, comprising of two main treatments i.e. No Leveling (L_0) and Leveling with laser land leveler (L_1) and five sub treatments *viz.*, zero till drill (M_1), roto till drill (M_2), strip till drill (M_3), raise bed planter (M_4) and conventional practices (M_5). The five sub-treatments *i.e.*, M_1, M_2, M_3, M_4 and M_5 were performed uniformly under L_0 and L_1. The experiment was performed in six replications for green gram crop under loamy sand soil in the research farm of Centre for Watershed Management and Participatory Research and Rural Engineering, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat State.

The result revealed that the treatment L_1 offered 5.79 percent higher effective field capacity (EFC), 0.77 percent more tractive efficiency, 3.40 percent higher power delivery efficiency, 7.62 percent less volume of soil disturbance, 6.50 percent more fuel efficiency, 6.33 percent less energy and 8.00 percent reduction in surface soil disruption than the treatment L_0. Among resource conservation machineries the treatment M_1 recorded higher effective field

capacity and tractive efficiency of 0.504 ha/h and 71.87 percent, which was correspondingly 51.78 and 2.05 percent more than M_5. M_2 presented maximum value of power delivery efficiency equivalent to 18.73 per cent, which was 19.59 per cent higher than M_5. M_1 recorded lowest soil volume disturbance (359.68 m^3/h) among sub-treatments, which was 38.65 per cent lower than M_5.

Fuel consumption and energy requirement presented by M_1 was lowest with corresponding value of 7.60 l/ha and 77.96 kWh/ha, which were 47.94 and 47.76 per cent lesser than M_5. The treatments M_3 and M_2stood second and third reporting fuel consumption equivalent to 8.51 and 8.91 l/ha, respectively.M_1 presented minimum surface soil disruption of 92.05 cm^2 which was lower by 50.99 per cent compared to M_5.

The result revealed that effect of L_0 and L_1 on soil cone index, bulk density and weed growth found non-significant in all three years as well as in pooled outcome. Treatments under L_1 offered higher moisture content (0.54 to 0.76 %) as compared to L_0.Soil cone index presented by M_1 was higher by 11.51, 12.80 and 11.26 per cent for 10, 35 and 60 DAS respectively than M5. The treatments M_3, M_2 and M_4 recorded subsequent value of soil cone index as 1770, 1721 and 1625 kPa on 60 DAS. M_2 offered maximum soil moisture content of 14.38, 15.34 and 12.79 per cent for 10, 35 and 60 DAS respectively, where as it was minimum for M_5 with a variation of 18.25 per cent as compared to M_2. The treatments M_4 and M_5 manipulated the top layer of soil profile which gave higher value of bulk density than M_1, M2 and M_3.

The treatment L_1 presented 5.43, 6.49 and 11.93 per cent better root length, plant height and higher yield respectively as compared to unlevelled plot on 60 DAS. Roto till drill presented maximum and significant value in terms of root length (19.21 cm), plant height (54.11 cm) and seed yield (823 kg/ha) which were 7.91, 6.41 and 7.89 percent higher than M_5.

The treatment L_0M_1 reported minimum total operational energy (1049 MJ/ha) where as maximum operational energy of 1538 MJ/ha was reported by L_1M_5. The treatment L_1M_2 was found to be most energy efficient for cultivation of rain fed green gram with maximum output: input ratio of 11.29 achieving 19.04 and14.79 percent higher value as compared to L_0M_5 and L_1M_5.

Economic analysis revealed that the treatment L_1M_2 (Leveling + Roto till drill) presented maximum net return of ` 36595 per hectare, specific cost of production`9.04 per kg and benefit: cost ratio of 4.64.

M.E./M.Tech (Chemical Engineering)

1. Synthesis, Characterization and Application of P-N junction based Photo-Catalytic Semiconductor material

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Studies of semiconductor based photo-catalytic system have attracted much attention for their wider applications have been focused in several aspects such as solar conversion and storage, reductive fixation of CO_2 organic synthesis, mineralization and detoxification of organic compounds from waste water by using variety of photo catalyst. In this view, the present work has been focused on the synthesis and characterization of some p-type metal oxides such as Mn_2O_3, Sb_2O_3, Zn-Te, Zn-Se have been doped in n-type metal oxides such as ZnO and TiO_2 to produce a nano-composite for degradation of methylene blue dye in aqueous solution.

The ZnO and TiO_2 based nano-composite photo catalyst were prepared by hydrothermal method, precipitation methods and thermal method respectively and it was characterized by Powder X-ray diffraction (PXRD), UV-Visible diffuse reflectance spectra (UV-DRS) and Scanning electron microscopy (SEM) to study their electronic, structural and morphological properties. The synthesized catalysts owns the band gap values were falls in the UV region which are confirmed with the UV-Vis DRS. SEM images evidences the morphology of all the synthesized catalysts shows hierarchical nano-rods. The photo-catalytic activity of the entire synthesized nano-composite was evaluated with the degradation study of methylene blue (MB-50 ppm solution) under UV irradiation. The result implies that up to 72 % degradation for ZnO and 98% degradation for TiO_2 nano-composite were achieved to degrade the MB content in waste water within one hour. The kinetic study reveals that the

initial rate for all the reactions in concern about the synthesized nano-composites was calculated to be in the range of 1.2-1.9 × 10^{-6} molL-1.

2. Optimization of biodiesel production through process intensification techniques using waste cooking oil

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Biodiesel is a renewable alternative fuel to petroleum diesel and produced by trans-esterification reaction between triglycerides and alcohol. The production via conventional process is difficult due to immiscible nature of both the reactants which cause poor mass transfer rate due to which it consumes more time and energy. Hence process intensification is required to reduce the time, energy required and to make the process environmental friendly for which ultrasound energy is one of the best alternatives. In the present research work, waste cooking oil has been used as feedstock to produce biodiesel using ultrasound energy (power 500W at 20 kHz frequency) for 20 minutes of reaction time. Homogeneous catalyst (KOH) and heterogeneous catalyst (CaO) were used for transesterification reaction. Optimization study was performed to analyze effect of various process parameters (viz. methanol-to-oil ratio, catalyst percentage and reaction temperature) on the yield of biodiesel using response surface methodology.

Various Physico-chemical properties of optimized biodiesel product were measured as per ASTM and DIN standards. Further, performance of biodiesel blends (B5 to B15) were tested on four strokes C.I. engine. The present method has potential for commercialization and can solve the environmental problems caused by the unused large quantity of waste cooking oil in Gujarat state.

3. Synthesis & characterization of Janus Particles

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The particles having anisotropic properties are called Janus particles. There is growing interest in amphiphilic Janus particles after first report on Janus particles appeared in the year 1985 by K.W. Lee and further worked by P.G. De Gennes, Nobel lecturer, in the year 1991. Herein, we developed the model of oil-in water emulsion system and investigated the structure & stability of the Pickering emulsion at different temperature with time, stabilized by the silica nano particles and to achieve the better stability, the liquid emulsifier is also used. The emulsion stability was observed by Particle size analysis. The silica particles partially masked onto the surface of wax and partially unmasked particles modified using the different surface modifying agents. The morphology of this modified surface observed under the SEM, FTIR.

4. Selective recovery of metals from used mobile lithium ion batteries.

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A hydrometallurgical route is developed for the selective recovery of metals from discarded mobile lithium ion batteries. Anode and cathode layers from the batteries were dismantled and were ground before leaching. Sulphuric acid concentrations ranging from 10-35% was used for leaching the metals. Leaching was carried out in four stages and the amount metals leached in each stage was determined. 10% acid strength gave better results in comparison to higher acid strengths.

Acorga and PC 88 were used as extractants to selectively extract copper, cobalt, aluminum, nickel, iron and lithium from the leached solutions. Copper was selectively removed using Acorga at low pH values and stripped using 1.5M sulphuric acid. Co-extraction of iron and aluminum was carried out using PC88A. Aluminium was selectively stripped using low acid strength whereas iron was stripped using higher acid strengths. Cobalt was recovered in the pH range of 3.5-6 using PC88A followed by nickel at higher pH values with only lithium remaining in the aqueous phase. A flow diagram is proposed for the selective separation and recovery of the metals.

5. Nickel Recovery from plating waste water and its application as a catalyst.

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Nickel was extracted from optical plating industry waste liquor containing 20 g/l nickel using 30% v/v of LIX 84Ias an extractants and kerosene as diluent. 90% of nickel extracted was recovered as its oxalate when the metal loaded organic phase was stripped with oxalic acid. Calcination of the oxalate at 400^0C converted the oxalate to oxide. The obtained nickel oxalate as well as nickel oxide were characterized using XRD, FTIR. No other metals present in the waste were detected in the XRD spectra indicating that the material was pure nickel oxide. The surface area of the synthesized nickel oxide was $55m^2/g$. The application of nickel oxide as a catalyst was checked for conversion of p-nitrophenol to p-aminophenol and the conversion of indoleandisatin to diindolyloxindole derivatives.

6. Research Project on Cleaner Technology: Clean Process for Sulfonation.

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The project is to apply the Novel technology for eliminating pollution caused by Sulfonation Process. Traditionally the Sulfonation is carried by Oleum or Sulfuric acid which causes lot of waste acid generation. This waste acid is difficult to treat or dispose of. Therefore, an alternative process is employed using gaseous sulfonating agent. As the new sulfonating agent has its own associated problem, a novel process route is developed using novel reactor, mist eliminator and compressor to recycle the sulfonating agent in gaseous form. The Novel mechanism comprises of Novel Jet flow Reactor, Mist eliminator, and compressor to complete the recycling of gaseous sulfonating agent. Other accessories are also required to add the make-up gas and Diluent.

Pilot scale equipment is ready and is tested for hydraulic and pneumatic test. It is now to be tested for actual system after performing Hazard analysis study.

7. Analysis of the Pyrolysis process for Plastic waste to fuel production

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Development and modernization have brought about a huge increase in the production of all kinds of plastic commodities, which directly or indirectly generate waste due to their wide range of applications coupled with their versatility of types and relatively low cost. The rate of plastic waste generation has increased steadily at 5% per year but recycling is only at 3% per year. The remains are either incinerated or disposed in land fills.

As a solution, Pyrolysis, thermo-chemical decomposition, provides an excellent alternative to convert plastic waste into valuable products, such as hydrogen and hydrocarbons which could be further processed for fuels and chemicals like syngas (steam reforming).Different techniques of converting plastics waste into fuel including thermal and catalytic pyrolysis, microwave-assisted pyrolysis and fluid catalytic cracking.

Under pyrolysis conditions, plastic wastes can be decomposed into three fractions: gas, liquid and solid residue. Pyrolysis studies oversimplify the mechanism of reaction by assuming first order decomposition, leading to inaccurate predictions of the process. This could cause big challenges in designing pyrolysers or scaling up pyrolysis process.

The aim is to carry out experiments with different conditions and catalyst to analyze the pyrolysis of plastic waste which could be implemented in the current recycling technology. As the calorific value of the plastics is comparable to that of hydrocarbon fuel, production of fuel from plastic waste would provide a good opportunity to utilize the waste as a better alternative to dumpsites.

8. Synthesis of lacoo3 by wet and dry chemical method for abating automotive co emission

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Perovskite oxides are alternative catalytic material to the noble metals used in Three Way Catalytic Converter for automotive CO oxidation because of their low cost, thermal stability

at high temperature and excellent redox properties. In the present study, an attempt has been made to synthesize $LaCoO_3$by citrate and reactive grinding methods. Prepared Perovskite were characterized by various characterization techniques such as XRD, BET, SEM, TEM, EDX, H_2-TPR and O_2-TPD. The catalytic activities of the Perovskite for CO oxidation were measured using a fixed bed reactor with simulated gas mixture containing 1% CO, 1% O_2 and balance N_2.

The $LaCoO_3$ catalyst prepared by reactive grinding for 11 h milling without heat treatment exhibited around 90% CO conversion at temperature less than 260 ^{0}C at high space velocity of 60000 $Ncm^3g^{-1}h^{-1}$ (GHSV). This catalyst subjected to time-on-stream stability test for 24 h at 300 ^{0}C during which it remained stable and exhibited 100% CO conversion. Perovskite catalyst prepared by reactive grinding deposited on ceramic monoliths via dip coating procedure and tested in 300 cc petrol engine.

9. Studies on Nutrient Removal from wastewater using Electrochemical Method

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The contamination of water resources by nitrogen compounds is a crucial environmental problem gaining attention in recent years. In the present work, anodic oxidation process has been explored as a potential alternative for urea rich wastewater treatment. The optimization of the influencing factors on electrochemical removal of urea was studied. Fabrication of various Dimensional Stable. Anode was accomplished by Standard Thermal Decomposition method. Batch experimental study was carried out with all fabricated electrodes to check the performance for removal of nitrogen species by electrolysis of urea rich wastewater under optimized conditions. This work also investigates the kinetic behavior of active species formed in electrochemical cell during electrolysis. Also, the best electrode was checked for removal of nitrogen compounds from actual urea rich industrial wastewater. Service Life and Characterization like SEM, EDX, CV and XRD were done to verify the electrochemical performance of the best fabricated electrode.

10. Preparation& evaluation of de-oxo-catalyst for purification of inert gases

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There has been phenomenal growth in the development of adsorptive technologies for the separation and purification of multi-component gas mixtures during the last three decades. They are being used to serve the chemical, petrochemical, pharmaceutical, environmental, and electronic gas industries. Two generic process concepts called “Pressure swing adsorption (PSA)” and “Thermal swing adsorption (TSA)” is most frequently used for industrial gas separations.

An important technique for producing nitrogen from air is pressure swing adsorption (PSA). Carbon molecular sieves and zeolites are the most well-known adsorbents in PSA frameworks for production of nitrogen, yet the primary disadvantages of presently accessible adsorbents are their high cost of production and final product fluctuation. A significant challenge around there of innovation is to improve the structure of carbon molecular sieves or to change the support from CMS to activated alumina to achieve higher air recoveries, higher nitrogen productivity, and better consistency in adsorbent properties-all at a lower cost. A simple PSA unit produces nitrogen up to 99.99% purity, with trace of (< 100 ppm) of oxygen impurities.

The ever increasing demands for high purity gases, used not only in chemical industries, are stimulating the use of high activity catalysts for the removal of impurities. Oxygen is a major impurity in inert or reactive gases; and hence, reducing its concentration has significant importance in industries. Adsorption of oxygen impurity from inert gases has become more popular now a day. Use of beverages and packed food stuff is increased and hence it is necessary to remove oxygen impurities from the atmosphere to preserve food stuff for a longer time.

Inertization of reactors and reaction space in many polymerization processes is required to enhance the productivity of catalyst and to avoid undesired products. Therefore, high purity

gases with purity of > 99.9999 % and < 1 ppm oxygen impurity is needed. Chemisorptions' with subsequent catalytic reaction always offers and economical and effective way to purify gases.

In the present study, adsorptive separation of oxygen from partially purified nitrogen was considered by chemisorptions route using in-house developed De-oxo type catalyst/adsorbent. Catalyst/adsorbent samples were prepared using dissolution technique. Different synthetic parameters such as metal salt loading, calcinations temperature, effect of co-metal were extensively studied to get the optimize recipe for the catalyst preparation. Prepared Adsorbents were characterized by various analytical techniques such as ICP-OES, Surface are measurements. The prepared adsorbent samples were evaluated through gas phase equilibrium Adsorption isotherm using volumetric set-up and oxygen adsorption capacity was measured at 230 ^{0}C. Sample prepared with transition metal salts like copper (Cu) and manganese (Mn) supported on γ-alumina (Al_2O_3) has maximum oxygen adsorption capacity and was found equivalent with reference samples. All the data were fitted into Temkin adsorption isotherm model to calculate the adsorbent/adsorbate parameters and Temkin constants for chemisorptions process with regression value (R) in the range of 0.99.

11. Instantaneous Generation of Sodium Hypochlorite disinfectant by electro chemical method

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Sodium hypochlorite which is produced using salt and raw water by electro chemical method. Low concentration sodium hypochlorite is been produced with electrodes like mixed metal oxides and titanium and optimization studies were done on these electrodes with different parameters. The foremost aim of present work is to compare and analysis the performance of various mixed metal oxide for production of sodium hypochlorite. The Ti/IrO_2-SnO_2-Sb_2O_5 electrode shows the cost effective and higher production.

The physico-chemical and electro-chemical properties as well as the hypochlorite performances of the electrodes were inspected. Result shows the recyclability of Ti/IrO_2-

SnO_2-Sb_2O_5 electrode shows 5 times and the concentration of sodium hypochlorite does not decrease as much low compared with other electrode. The phase composition and morphology in these products are characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM). Energy consumption is calculated based on production of sodium hypochlorite. The cost of sodium hypochlorite produced from Ti/IrO_2-SnO_2-Sb_2O_5 electrode is 0.019 Rs. /L while the market price is 1.2 Rs./L with the concentration of 1%.

12. Bio Gas to Methanol: Enzymatic Conversion of Methane

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Methanol has involved reproduction of an unconventional transport fuel when merged in several extents and is presently under deliberation for wide-ranging use. Various scientists have stated on the finish products of the an-aerobic fermentation process as bio-gas and methane but the useful middle way yields. In, an-aerobic digester waste by means of methanol has usually been unnoticed. Thus the core focus of this study is to examine the intermediary product of an-aerobic co-digestion of bio-gas. Bio-gas is a renewable energy source, but its transportation is a major issue. So we are tried biogas is converted to methanol as anaerobic co digestion process using different bio solids. This work is directed in an atmospheric condition of lab-scale batch bioreactor using a stable holding time. Sweet potato, potato, banana peels, neem leaves, maize, gram and boiled rice are the bio-solids used. Methanol was evaluated using Gas Chromatography (GC). It was observed that, maize and boil rice substrates with cow manure inoculum and goat manure have the maximum probable for methane making via an-aerobic co-digestion. This work demonstrates that the methanol occurs as an intermediate product of an-aerobic co-digestion. Lastly, we have concluded that this work determines through augmenting the manufacture of methanol at intermediary stage can decrease the making of methane gas.
Keywords: Bio-gas, Methanol, Bio-solids, anaerobic co digestion

13. Study on Feasibility of Bioremediation after Oil Recovery for Kadi-Kalol Area.

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Bio-remediation is an advanced justification of natural environmental process mechanism of removing contamination from land by enhancement of microorganisms to faster rates, saving natural time consumption and providing betterment of soil properties. The main aim of this work is to degrade the poly aromatic hydrocarbons (PAHs) from the crude oil contaminated soil leading to land reclamation and studying the potential of bioremediation. This had been achieved by giving treatment to contaminants by application of cultured microorganisms in-situ or ex-situ. The experiments were carried out at laboratory level and six different batches of soil at different contamination levels. At fixed span of time intervals having 10 to 15 days these batches were examined for the degradation percentage by solvent extraction technique followed by gravimetric analysis. The graphs of concentration of PAHs versus time intervals were plotted for each contamination level. The rates of degradation of PAHs were calculated and we proposed the kinetic rate expressions for PAHs degradation and growth-rate expression for microbes. We had also studied the effects of phyto-remediation, and obtained better degradation results with probable rate expression.

14. Biogas to Methanol: Enzymatic Conversion of Carbon Dioxide

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Biodegradable wastes which comprises of agricultural wastes, kitchen wastes and animal wastes can be used to produce bio-gas which is a powerful greenhouse gas. Bio-gas comprises of around 60 percent methane and 40 per cent carbon dioxide. Strategies have been made for conversion of carbon dioxide to useful products in order to minimize greenhouse effect as well as add in efficient production of fuel alternatives. The main aim of this effort is the conversion of Carbon dioxide into value added fuel, i.e. Methanol. Conversion of carbon dioxide to methanol can be done by many methods enzymatic catalysis is used over conventional processes for its advantages like it can be operated at ambient temperature and pressure, it is environment friendly, it is cleaner, faster and easier to operate than microbial

process. Conversion of carbon dioxide into methanol is done by co-encapsulating the three dehydrogenase in calcium alginate. The complete method involves of three stages: reduction of Carbondioxide to formate using Formate dehydrogenase (FateDH), reduction of Formate to Formaldehyde using Formaldehyde dehydrogenase (FaldDH), and reduction of Formaldehyde to Methanol using Alcohol dehydrogenase(AD H). Reduced Nicotin-amide Adenine Di-nucleotide (NADH) acts as an electron donor for each dehydrogenase-catalyzed reduction.

15. Optimizing Process Parameters for Maximizing Yield of Bio-Diesel Obtained from Transesterification of Kusum Seed Oil.

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Biodiesel derived from plant oil including edible and non-edible oils has gained much importance in last few years because of most serious environmental problems. Kusum (SchleicheraOleosa), belonging to the Sapindaceae family have been studied to evaluate its suitability as potential feedstock for biodiesel production. As Kusum oil content high free fatty acid (3.94%), the two-step process is the best way to utilize Kusum oil. Acid Esterification was used as pre-treatment to reduce FFA contents from oil and influences of different process variable on acid value of Kusum oil were studied. Maximum acid value reduced 0.50 mg KOH/g (93.20%) from 7.83 mg KOH/g by its pre-treatment with methanol to oil molar ratio 9:1 using H_2SO_4 as catalyst 3 wt% in 60 min reaction at 60°C. After pre-treatment, Kusum oil was used for the final alkali-catalyzed transesterification reaction.
Response surface methodology based on central composite design (CCD) was used to optimize process variable. The optimum combination for maximum KOME yield (94.86%) was found to be methanol to oil molar ratio 9:1, catalyst amount 1 wt% at reaction temperature of 60 °C in 75 min reaction time. High conversion of KOME was confirmed by acid value test, FTIR analysis and TLC analysis.

M.E./M.Tech (Environment Engineering)

1. A Study on Conversion of Waste Plastics to Liquid Fuel Using Thermal Pyrolysis Process for Effective Plastic Waste Management.

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Plastics are synthetic product produced from a wide range of polymers The property that makes it so ubiquitous to use is that it can be molded to the desired shape and once set can serve the desired purpose. Since they are lightweight, inexpensive and durable it finds its use in a wide range of applications. The easy availability of plastics has led to its exploitation and careless use. This excessive usage caused the accumulation of huge amount of plastic waste into the environment. Plastics have a very high life in the environment and do not disintegrate through the natural process in the environment. So, the plastic disposal without any effective technique accumulates the waste into the environment certainly causing pollution. Researchers have shown that since plastics are a product of petroleum they have the efficiency to be used for fuel production which will solve the problem of plastic disposal and the rising fuel crisis. In this project, the technique of Pyrolysis is used for thermal degradation of the plastic waste. The pyrolysis oil obtained from the prototype was analyzed in a NABL and FDA certified laboratory. It was observed that the oil obtained after pyrolysis had combustible properties and diesel range compounds. The residue left over was also analyzed which showed that it had bitumen like properties.

2. Study of Bio methane Production from Household Waste for making small scale model

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Energy shortage in developing countries is one of the major challenges for sustainable development. Indian cities are running out of land for waste dump. The solution to make our country free from such challenges is to make small scale household bio-fuel generator, which is generated from household waste. Municipal solid waste in developing countries has high amount degradable organisms. As per Current research agenda, production of Bio Methane from co-digestion of thermos-alkaline pre-treated segregated waste is generated under controlled condition. In co-digestion process, by using short-chain fatty acids and various enzymes as a inoculum it will help in increasing rate of Methane production and will decrease retention time of degradation waste. To accomplish this idea the model is being prepared which is compatible and easy to use in households, which can also be used in day-to-day life and get high concentration of biogas. Its making is economic so that people in rural and urban area can use and overcome problem of waste management and generation of lesser waste. Advantage of this process is that, the Digested waste can be used as a fertilizer on the basis of its characteristics.

3. Resource efficient & cleaner production and up-gradation of effluent treatment plant in pesticide industry.

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The study has been undertaken to improve the up-gradation of ETP and Resource Efficient & Cleaner Production in pesticide industry located at Baroda. It has been done in two phases, one phase was for up gradation of Effluent Treatment Plant and another phase was for resource efficient and cleaner production. Up gradation of ETP was done by its adequacy and efficacy. The overall performance of the ETP was evaluated considering all the dimensions and actual flow, Hydraulic Retention Time (HRT), Surface overflow rate (SOR), etc., of units and Compare with a recommended range then identifying whether the design is adequate for that flow or not. ETP efficacy done with collected wastewater samples at each stage of treatment units and analyzed for the major wastewater quality parameters, such as pH, Chemical Oxygen Demand (COD), Total Suspended Solids (TSS) and Total Dissolved Solids (TDS), Ammonical Nitrogen, Oil & Grease. The results obtained by the study suggest that the volume of collection tank 805.5 m^3 is very large as compared to a flow of 98 m^3/d and

Return activated sludge flow rate should be maintained at the rate of 60% of the influent flow rate. In Ammonical nitrogen of treated wastewater was more than the permissible limit of CETP. The lab scale study was done for Ammonical nitrogen removal by Fenton treatment. In this treatment removal efficiency of Ammonical nitrogen was obtained in the range of 75-85%. And the Resource Efficient & Cleaner production was done for pesticide product perfenofos and Chlropyrifos. The result was obtained by mass balance study of chemical reactions, excess of TMA 74.8 % was used in production and yield of the product was 86.3 %, the by-product NaBr can be utilized in generating of Bromine by treating with chlorine gas. For Chlropyrifos, The result was obtained by mass balance study of chemical reactions, excess of NaOH 88.58% was used in production and yield of the product was 53.12%. Cleaner production options, identifying to reduce the losses of resources have been identified.

4. Evaluation of Phyto-capping as sustainable solution for covering sanitary landfill sites

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Landfill gases (LFG) are produced due to biodegradation of organic fraction of municipal solid waste (MSW) when water comes in contact with buried wastes. The conventional approach like clay capping is still practiced to mitigate the percolation of water in landfills in India. Gas extraction system, for gas collection from landfills, is proven to be an expensive technique. Thus, "Phytocapping" to mitigate landfill gases and to minimize percolation of water into the landfill can be an alternative. Laboratory-scale study on Phytocapping using five Indian native plants in 3 planters (50 cm * 30 cm * 38 cm) in 7 kg of MSW was carried out. The municipal waste that was collected from the solid waste transfer station had moisture content 42% , volatile solids 24% and ash content of 0.22% , COD 4793.9 mg/l and pH 6.28. The soil had moisture content 15%. Five species of Indian plants with locally available soil and waste were tested for the purpose of methane mitigation, heavy metals remediation from leachate and overall soil-plant interaction. Methane oxidation due to vegetation was observed compared to non-vegetated planters. Root zone methane concentrations were monitored for plant species. The study demonstrates the methane oxidation and heavy metals remediation.

5. Anaerobic sequential batch reactor (AnSBR) – microbial fuel cell (MFC) integrated system for dye de-colourisation, COD Removal, and bioelectricity generation

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The purpose of this study was to investigate the treatment of synthetic Reactive Black 5 (RB5) dye wastewater by single chamber AnSBR-MFC integrated system in which molasses was used as a simple substrate. With the use of carbon fiber brush as a bio-anode and Air cathode, de-colorization of azo dye RB5 occurred under anaerobic condition along with conversion of chemical energy contained in organic matter into electricity by microorganisms. The capability of AnSBR-MFC for simultaneous molasses and RB5 dye removal was investigated. Maximum removal efficiencies observed for COD and color were 79.35% and 81.52% after 72 h, when inlet RB5dye concentrations were 15 mg/L and 10 mg/L respectively, and 1.31 g/L molasses used as a substrate. Maximum power density obtained was 11.67mW/m2 after 23 h, when RB5 dye concentration was 20 mg/L and 1.31 g/L molasses used as a substrate.

Thus, AnSBR-MFC provided dual advantages of COD and color removal without any energy input, and production of bioelectricity from an inexpensive carbon source, molasses.

6. Anaerobic biodegradation of high strength wastewater stream Generated from manufacturing of Solvent Black 46 (SB 46)

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This study demonstrates treatment of real wastewater from manufacturing of Solvent Black 46(SB46) dye in up flow Anaerobic Sludge Blanket (UASB) Reactor. Consistent COD removal efficiency of around 90% was achieved at an organic loading rate (OLR) of 2 kg COD/ m3 d at inlet COD of 20000 mg/L. Effect of varying OLR on COD removal efficiency and methane production was evaluated by feeding wastewater at COD of 10000 mg/L. The COD removal efficiency of >90% at OLR of 2 gradually decreased to ~80% at OLR of 4 kg COD/ m3 d. Similarly, % Decolorization decreased from 85% to 68% with increase in OLR.

Methane production was 85-95% of theoretical methane formation (i.e. 350 L/kg COD removed) at OLR 2 kg COD/ m3 decreased to 40-50% at OLR of 4 kg COD/m^3 d. Decolorization of wastewater led to generation of aromatic amines indicated by formation of a new peak at 286 nm in UV-V is spectrum. Inlet pH of feed was in the range 6-6.3 which increased to 8.5-8.6 indicating degradation of acetate in the wastewater. Results of this study suggest that anaerobic treatment can be employed advantageously for SB46 wastewater, resulting in excellent COD removal without any energy input and producing useful methane.

7. Treatment of real Dye wastewater by different AOPs

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Dyestuff are very high in colour, pH, temperature, COD, biodegradable materials. Treating dye wastewater by conventional treatment process is not effective as dye effluent contains certain compounds. The present research includes mainly removal of COD from dye wastewater about three different AOPs: Fenton's treatment, coupled Fenton + Ultrasonic cavitation, coupled Fenton+ Ultraviolet Radiation treatment. Fenton's treatment involved adjusting initial pH to 2.0, 2.5, and 3.0. Adding Fenton's reagents i.e. FeSO4·7H2O based on H_2O_2/Fe^{+2} molar ratio as 10:1, 15:1, 20:1 followed by adding drop by drop H2O2 based on COD / H_2O_2 concentration ratio as 2:1, 4:1 and 6:1. The reaction is allowed to run for 3hrs. Ultrasonic cavitation is of 20Hz at 172sec. cycle and Ultraviolet radiation is provided by 2 mercury tubes of 14watts. Results showed Fenton + Ultrasonic cavitation treatment is the most efficient method in reducing COD up to 87% i.e 539mg/l .Initial COD was 2860 mg/l at COD / H_2O_2. The biodegradability of the wastewater was checked by performing Zahn-wellens test.

8. Design of pilot plant for recovery of precious and base metals from e-waste using electro winning process

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Currently the E-waste is either land filled or incinerated which is not enviromentally viable. The metals if recovered can be economical as well as eco-friendly. Four metals are targeted; Gold, copper, silver and Palladium which are recovered in their most efficient and purest form. The process has been divided into four stages. In the first stage, the size reduction of the material is carried out using shredder and pulveriser. Then in the second stage the metals and non-metals are separated using Corona electrostatic separator and after that the ferrous and non-ferrous are separated using the Magnetic separator. The Non-ferrous metals contain the four targeted metals which are to be recovered. The separation is followed by the leaching process in the third stage. The separated non-ferrous metals contain impurities which are dissolved by Sulphuric Acid leaching. The targeted metals remaining are leached in Aqua Regia. The solution is then subjected to Electro winning process. The cells for electro winning are arranged according the voltage requirement and a continuous format. Firstly, the copper from the solution is recovered, followed by gold, silver and palladium. The metals obtained here are 99.99% pure. The last stage involves the by-product stream and effluent treatment according to the environmental, health and safety standards. The economical and techno-commercial view of the project has also been considered here.

9. Wastewater treatment of soap manufacturing industry by advance oxidation process

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The effluent treated with ultrasound alone by ultrasonic stirrer for 120 minutes of reaction time. 73.58 % of COD removal achieved with 120 minutes of reaction time.

In the Fenton treatment, the dose of Fe and H_2O_2 decided by parameters like pH, COD to H_2O_2 ratio and H_2O_2 to Fe ratio. Vary the pH (2, 2.5 and 3), COD to H_2O_2 ratio (8, 6 and 4) and H_2O_2 to Fe ratio (10, 8 and 6). From the results, it is shown that there is maximum 73.29 % of Color removal achieved with pH: 3, H_2O_2 to Fe ratio 6, COD to H_2O_2 ratio 8, maximum 58.87% of TDS removal achieved with pH: 3, H_2O_2 to Fe ratio 10, COD to H_2O_2 ratio 8, maximum 32.70 % of TSS removal achieved with pH: 3, H2O2 to Fe ratio 10, COD to H_2O_2

ratio 4, maximum 88.97 % of COD removal achieved with pH: 3, H_2O_2 to Fe ratio 8, COD to H_2O_2 ratio 8, maximum 95.55 % of BOD removal achieved with pH: 3, H_2O_2 to Fe ratio 10, COD to H_2O_2 ratio 8.

The Ultraviolet treatment in combination with Titanium Dioxide and Hydrogen Peroxide is used for treating the wastewater.

The amount of TiO_2 and H_2O_2 decided by COD to H_2O_2 ratio (8, 6 and 4) and TiO_2 to H_2O_2 ratio (6, 7 and 8).The max. Color reduced by 94.74 % with pH value 6.5, COD to H_2O_2 ratio 4 and H_2O_2 to TiO_2 ratio 6, max. TDS reduced by 63.59 % with pH value 6.5, COD to H_2O_2 ratio 4 and $H_2O_2$to TiO_2 ratio 8, max. TSS reduced by 76.67 % with pH value 6.5, COD to H_2O_2ratio 4 and $H_2O_2$to TiO_2 ratio 6, max. COD reduced by 97.85 % with pH value 6.5, COD to H_2O_2ratio 8 and $H_2O_2$to TiO_2 ratio 8, max. BOD reduced by 98.52 % with pH value 6.5, COD to H_2O_2ratio 8 and $H_2O_2$to TiO_2 ratio 8.

10. Optimization of the treatment of dye intermediates wastewater by hydrodynamic capitation and its combinations.

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Dye intermediates wastewater consists of organic refractory compounds which cannot be degraded with biological treatment, therefore they are treated with Advanced Oxidation Processes which transform complex organic refractory compounds to simpler compounds such as CO2 and H2O.This work presents treatment of dye intermediates wastewater by Hydrodynamic Cavitation, by combining it with other treatment followed by further optimization with BOX BEHNKEN design of Response Surface Methodology. Hydrodynamic Cavitation is one of the latest emerging AOP which uses Venturi as a cavitation device in order to generate cavities. These cavities get collapsed and generate OH• and H• radicals which react with organic refractory pollutants in dye intermediates wastewater and provides the treatment with a view to bring reduction in COD. Present work describes treatability studies which has been carried out by treating the wastewater with Hydrodynamic Cavitation and its combinations.. Treatment of Hydrodynamic Cavitation was combined with Ozonation. Various runs were taken of the combined treatment with

Hydrodynamic Cavitation and with Ozonation at different pH and for different time interval. Maximum removal of COD of 77.125% was obtained when dye intermediates wastewater was treated with Hydrodynamic Cavitation and Ozonation for time interval of 3 hour at pH 6.

11. Fat Degradation of Dairy Industry Effluent using An-aerobic treatment

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The dairy industry is among the most polluting of the food industries in volume in regard to its large water consumption. Due to the increase demand of milk and milk products, the dairy industry in India is expected to grow rapidly and their by the dairy effluent is expected to pose environmental pollution problems in the future. Wastewater from the dairy industry is highly polluting, considering both the volume generated (2 ~ 6 L of effluent per L of processed milk) and its high organic load. Dairy effluent contains high contents of fats, oils, suspended solids, nutrients, and organic matter. From that, fats, oils and grease (FOG) adversely affect the aerobic and anaerobic treatment of effluent. Accumulation of FOGs in wastewater collection of pipes, appearance of unpleasant condition and odor problems. Biodegradation of FOG in dairy wastewater has been a major challenge for the dairy industry. So it is necessary to treat FOG from dairy effluent separately. Present study is related to anaerobic degradation of FOG using different combination of selected cultures. Five set-ups of anaerobic digesters were successfully operated at ambient temperature. Different combinations of cultures were prepared for the feeding of digesters. COD and Oil and grease were analyzed in anaerobic digesters having different combinations of cultures for 0 day, 7 days, 14 days, 28 days and 42 days. Based on results obtained up to 42 days of digestion period, % COD reduction of 87.27% and 80.73% were obtained for culture C_1 (*Bacillus-1*) and culture C_2 (*Bacillus-2*). And % Oil and grease reduction of 80.25% was obtained for culture C_2 (*Bacillus-2*). So treatment of fat waste using culture C_2 (*Bacillus-2*) was more effective.

12. Air Pollution Control/ Material Recovery – Gas-Solid Separation.

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The present work has been done to determine the overall and grade collection Efficiency of wet cyclone separator for sub-micron particles on a laboratory scale basis. Laboratory scale model was designed and fabricated based on the high efficiency Stairmand model. Fly-ash was used as the test aerosol with d50 of 19.09 µm. Three spray nozzles with different flow capacities were used for scrubbing and tap water was used as the scrubbing Medium. Liquid to gas ratio and input power were selected as the two independent variables. Experimental trials were conducted for both dry and wet mode of operation. Liquid to gas ratio used for the experiments was 0.12, 0.43 and 0.77 L/m3 and input power as 55.20, 60.11, 73.60 and 87.90 Watts. The overall efficiency reported for the test aerosol was 84.40% for dry mode of operation and 88.54, 90.93 and 95.16 for wet mode of operation with increasing liquid to gas ratio and input power. The collection efficiency for particles having size below 2.5 µm was reported as 46.70% for dry mode of operation and 74.57%, 83.21% and 94.23% for wet mode of operation with increasing values of independent variables respectively. Increase in liquid to gas ratio had significant impact on the collection efficiency for particle size below 2.5 micron, for coarser particles the change in collection efficiency was not found significant. The equipment effectively separated liquid droplets from air stream and pressure drop values for both dry mode and wet mode of operation were identical.

13. Resource optimization of industry and up-gradation of effluent treatment plant

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The resource optimization was done for pesticide product. The result was obtained by mass balance study of chemical reactions, excess of TMA 77.68 % was used in production and yield of the product was 86.3 %, the byproduct NaBr can be utilized in generating of Bromine by treating with chlorine gas. Different cleaner production options and to reduce the losses of resources have been identified. Up-gradation of ETP was done by its adequacy and efficacy. The overall performance of the ETP was evaluated considering all the dimensions and actual

flow, Hydraulic Retention Time (HRT), Surface overflow rate (SOR), etc., of units and Compare with a recommended range then identifying whether the design is adequate for that flow or not. ETP efficacy done with collected wastewater samples at each stage of treatment units and analyzed for the major water quality parameters, such as pH, Chemical Oxygen Demand (COD), Total Suspended Solids (TSS) and Total Dissolved Solids (TDS), Ammonical Nitrogen, Oil & Grease. The results obtained by the study suggest that the volume of collection tank 805.5 m^3 is very large as compared to a flow of 98 m^3/d and Return activated sludge flow rate should be maintained at the rate of 60% of the influent flow rate. In Ammonical nitrogen of treated wastewater was more than the permissible limit of CETP.

14. Treatability studies on in-situ chemical oxidation for the Treatment and removal of colour from groundwater

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This study has been carried out on lab scale to test the effectiveness of In-Situ Chemical Oxidation (ISCO) technology to remove color from the contaminated soil and groundwater. ISCO is basically an In- Situ remediation technology where chemical oxidation treatment technologies are implemented to treat contaminated environmental media in its original place without removing it from its place. For achieving this purpose, two strong oxidants were used i.e., Hydrogen Peroxide along with ferrous sulfate as activator and Sodium Hypochlorite as another oxidant to increase the efficiency of H2O2 and Sodium Per-sulfate along with NaOH as activator. In order to verify the theoretical concept of ISCO, Proof of concept study was initially carried out. For the POC study, efficiency of color removal was qualitatively checked along with the stability of oxidants. Based on POC interference, experimental trial runs were executed with different doses until an optimum dose was achieved. The experiments were performed separately on soil slurries (with groundwater) and groundwater only (without any soil) to determine the Optimum conditions and oxidant demand to remove color from sample. Treating with soil slurries was found difficult because of the reactive nature of soil and high content of iron present in soil which activated the oxidants to large amount and was not able to control with stabilizers also.

15. Removal of cyanide from electroplating baths at ISRO, Ahmedabad

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The project work focuses on the treatment of cyanides from spent electroplating baths at ISRO, Ahmedabad so as to render them harmless and dischargeable to effluent treatment plant or any other sink directly. Series of experiments were done with three oxidants namely sodium hypochlorite, hydrogen peroxide and ozone, in order to derive the best possible treatment option for cyanide. Also, the optimum conditions required for complete cyanide removal with these oxidants were studied. The dosage of sodium hypochlorite, hydrogen peroxide for complete cyanide removal came out as 7-10g of NaOCl/g of cyanide and 4-8g of H_2O_2 /g of cyanide respectively. Ozone dosage came out as 1.8-4.6g of ozone/g of cyanide. From the comparison of results for NaOCl,H_2O_2,O_3,ozonation was derived as the best possible option for treatment of cyanides in Electroplating Baths at ISRO, Ahmedabad, considering ozone dose (1.8-4.6g O_3/g of cyanide),lesser reaction time (0.75-1.5 hours),no generation of precipitates, no harmful gas production and no strict pH or other operating condition requirement.

16. Optimization of Hydraulic Retention Time using Membrane Bioreactor for Treatment of Municipal Wastewater

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Today, world is facing the problem of water scarcity and its increasing thereafter. To solve or decrease the problem, the solution is to treat the wastewater and used it again. Membrane Bioreactor technology is one of the best option for this problem. The advantage of using MBR technology is, it gives high quality effluent with effective removal of solids, nutrients, organics, microbial contaminants etc. with uses very less space footprint and less sludge production. But it is still not used instead of Activated sludge process (ASP). On the contrary it has high capital cost, high cost of membrane replacement, high energy cost and fouling problem. HRT is directly affected the performance of membrane operation and permeate

quality. Generally, MBR works on 7-8 h HRT in the field. The aim of this study was to optimize HRT. The benefit of it was reduction in capital cost as well as maintenance cost of MBR. To achieve the goal of this study, firstly start-up of pilot plant was required for proper bacteria acclimatization. It took 1.5 months to complete. The second stage was to select the HRT for experimental work. For selection of HRT, batch test was carried out and from the results of batch test, the selected HRT was 5 h, 3 h and 1 h. The pilot plant was successfully operated on 5 h and 3 h HRT. But on 1 h HRT, pilot plant was failed. So, further analysis was carried out on 2 h HRT. The conclusion from this experimental work was that, pilot plant can be worked on 5 h, 3 h and 2 h HRT. But the best option was to operate the MBR plant at 2 h HRT. The benefit of operate the plant on 2 h HRT was, it can treat 2.5 times more quantity of wastewater than 5 h HRT can treat and around 1.7 times more than 3 h HRT can treat. The benefit was reduction in operational cost. The operational cost of MBR when operated at 2 h HRT was 2.5 times less than MBR operated at 5 h HRT and 1.5 times less when plant was operated at 3 h HRT.

17. Techno Economical Study on Eco-friendly Green Brick Production Using Reclaimed Sand Dust Waste

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In India, Metal Casting Industry is one of the oldest sectors. Most of this industry preferred sand casting molding system for casting of metal. A large quantity of sand waste is generated by reclamation process in cyclone separator and bag filter. This generated sand waste is disposed in landfill site and dumping site. Disposal of sand dust waste causes environmental pollution. Thus reclaimed sand dust waste has become an environmental menace. The paper here presents utilization of RSDW (Reclaimed sand dust Waste) in fly ash brick as a replacement material of fly ash. RSDW is replaced with fly ash in different proportions like 20%, 40%, 60%, 80%, and 100%. In this paper detail discussion of compressive test and result is represented.

B.E./B.Tech (Chemical Engineering)

1. Electricity production using "The Urine Cell".

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Electricity is one of the primary needs of human kind. Currently India's total installed power generation capacity is 300 GW which includes 42 GW of renewable energy sources, including Solar and wind. India is the world's third largest electricity producer and fourth largest consumer of electricity still lagging in 18% in Power generation. Today more than 35% of the Indian Rural villages have no access to electricity. Renewable energy sources known as clean technology and having zero environmental impact are the solution of above problem. So to overcome this problem, Renewable energy source is required. Urine possesses some biological properties which makes it unique for generating electricity. Fuel cell generates power by using bacteria to turn organic matter into electricity. It is easily available and routine wastage of all human kind. The microbial fuel cells work by employing live microbes which feed on urine (fuel) for their own growth and maintenance. This approach is to generate electricity with help of urine known as Microbial Fuel Cell (MFC) which usually generate 800 to 900 mV / liter on continuous feed of Urine. It is the carbon-neutral way of generating power. Six different combinations of electrodes are used in the process.

2. Energy Intensification of Dye Industry

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The dye industry is one of the oldest chemical business compositions in the world trade and textile manufacturers in India. Today, the wheels have turned full circle and India export dye stuff to the very same countries on which it was dependent till recently. Energy/process

intensification is a concept that is recently introduced in the chemical industry for the purpose of reducing environmental emissions, energy consumption and material consumption. Novel techniques utilized for energy intensification particularly concerned with such as equipment and plant minimization, alternative energy conversion and intensified plant operations. This is a strategy aimed at transforming conventional chemical processes into more economical, productive and green processes for cleaner production of the industry.

3. Extraction of Natural Dyes from Flowers, Leaves & Household Plants

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Dyes are the chemical substance that imparts its color on other substance. The key objective behind undertaking this project is to produce fine quality of dye product by using plant materials such as Rose Petals, Marigold, Flowers and Leaves of Asopalav Trees etc. as a raw material. This leads to the production of Eco-friendly, Hygienic form of dyes which can be used as an alternative form of synthetic dyes that are produced in various chemical industries with the use of various toxic chemicals containing Nitrite, Amino & Azo group that generates large amount of toxic & hazardous industrial waste as effluents. In order to extract dyes from the raw materials conventional extraction methods are to be carried out in the laboratory.

Those conventional methods are: Acidic Extraction, Basic Extraction, Alcoholic Extraction, and Aqueous Extraction. For Acidic Extraction 50%, 60%, 70% solutions of Nitric Acid &Sulphuric Acids are to be used. For Basic Extraction 50%, 60%, 70% solutions of NaOH are used. For Alcoholic Extraction 50%, 60%, 70% solutions of Methanol, Ethanol& Isopropyl Alcohol is used. The dyes solution obtained are then treated with the drying agents Anhydrous Sodium Sulphate& Sodium Carbonate in order to obtain the dry form of dyes. The boiling point of each of the dyes sample obtained is checked with the help of boiling point elevation method. From this the molar mass of the dyes sample are estimated which can be further used in Nitrite Value estimation of dyes in order to check the purity of dyes sample than the Mordanting solution of dyes are prepared with the use of mordant's such as Stanous Chloride, Potassium Dichromate, Potash Alum etc. The dyeing test is carried out by

imprinting the dyes in the Cotton & Wool fabrics. Other than this the value of Absorbance& Fastness is estimated for each of the dyes Sample.

4. Studies on extraction of essential oil from Palmarosa using green extraction technique

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Cymbopogon Martinii (Palmarosa), an essential oil bearing mandate industrial grass of India, is highly valued by cosmetics and perfumery industries for its rose like sweet odor from its inflorescences and leaves. Using microwave radiation, essential oil from the leaves of palmarosa was extracted for maximization of yield of oil, yield of geraniol and zone of inhibition (ZOI) as responses. For this purpose, various process parameters viz. solid loading, water volume, microwave power and extraction time were studied in detail and optimized using the Taguchi method and grey relational analysis. Hydro distillation was performed for comparative analysis. In hydro distillation, the responses were influenced by solid loading, volume of water, size of leaves and extraction time.

The optimization of process parameters was performed using the Taguchi method and grey relational analysis. Artificial neural network (ANN) was used for prediction of the results. Proximate and ultimate analyses were carried out to find the quantitative energy content of the used palmarosa leaves by finding its higher heating value (HHV). Results obtained in the present work can provide a platform to initiate various studies. The results can be used as a benchmark to carry out higher scale study.

5. Resource recovery of heavy metal containing sludge (HMS) for bricks production

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Significant quantities of sludge are generated as a waste material or by product from steel industries. They usually contain considerable amount of heavy metals, which causes serious

environmental issues on disposal to landfill sites. Therefore it is desirable to recover the valuables and utilize these wastes. The aim of present study was to investigate the accessibility of sludge obtained from effluent treatment plant of steel industry for the production of Bricks, which was sponsored by local steel surface finishing industry. Study shows that 40% substitution of ETP sludge with conventional clay assigned optimal proportion for the production of good quality of brick in terms of less water absorption and reasonable compressive strength.

6. Cleaner Production: Wastewater Treatment

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Wastewater from industries has an extremely adverse effect on environment & it is needed to be treated. Conventional wastewater treatment processes such as filtration, floatation, sedimentation etc. are relatively inefficient in removing & treating small suspended particles & hazardous chemicals from industrial effluents. So, there was a need to look for another wastewater treatment technology that can overcome the limitations of conventional processes. Thus, we have chosen our system: Electro-coagulation combined with Advanced Oxidation Processes.

7. Waste water treatment by hybrid Electro-Fenton and UV process

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Organic component especially aromatic compound is the main pollutant in industrial effluent. Convectional waste water treatment process is in-efficient for the removal of these types of toxic and hazardous pollutants. Electro-Fenton and UV which are advances oxidation process is powerful for degradation of most of organic compound including toxic and non-biodegradable. Electro-Fenton utilizes Fenton reagent to produce hydroxyl radicals. This experiment is carried out to find the percentage removal of COD and TDS by combined process and to optimize the parameters.

8. Zero liquid discharge

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Zero Liquid Discharge (ZLD) – A waste water management strategy that eliminates liquid waste and maximizes water usage efficiency. Although implementation of ZLD reduces water pollution and augments water supply. The numerous treatment methods used at these ZLD facilities along with their merits and detractions of each method.

9. Green approach to treat textile waste water using natural coagulants.

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As a point of view of safety of environment, now a day, disposal of untreated effluents from Textiles and dyes industries is major problem. Many industries use synthetic dyes for coloring their products. Effluents from textiles and dyes industries contain pH, TDS (Total Dissolved solids), Suspended solids, C.O.D. (Chemical Oxygen demand), B.O.D. (Biological Oxygen Demand). Indeed, the treating of effluent is recommended due to high level of contamination. There are many methods for treatment of effluents but, here reduction of C.O.D. value from effluent by eco-friendly method, this is done by jar-test using natural ingredients. This method is cost effective and also efficient Sometimes than commercial activated carbon.

10. Removal of heavy metals from waste water by using low cost adsorbents

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In this project work we will reduce the metal concentration of heavy metals by adsorption because of its low operating cost and efficient work. We are reduce the concentration of copper, and zinc by using low cost adsorbents such as treated news paper pulp, bananas and orange peels, tobacco stems, Neem peels with varies process parameter such as temperature, adsorbents dosage, contact time, initial concentration, PH etc.

11. Wastewater Treatment by Electro-Chemical Oxidation Process

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In the current century, disposal, treatment and reuse of all kind of wastes are the topmost priority in front of all countries. India, our country is also passing through the same problem. Due to reduction in availability of fresh water and raising the population level, all the country is forced to reduce their water consumption. Such kind of reduction will be possible only if treatment of wastewater can be done effectively. Numerous researches are going on for the treatment and reuse of industrial wastewater. Among all, electrochemical methods are proved to be very effective. Although at lab scale, the method of electrochemical is proved effective, it is not yet accepted in the market. The reasons are treatment requires specialized electrode material and design. The present investigation is a step towards the design of metal oxide coated electrode known as DSA (dimensionally stable anode) and application of those indigenous electrodes for the treatment of wastewater in terms of color and COD removed.

12. Sustainable eco-friendly brick

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The Project is aimed to discuss about manufacturing of eco-friendly brick. For production of high quality brick, sugarcane baggasse ash used as main raw material. Use of conventional brick in construction industry will lead to extensive loss of layer of fertile soil due to digging of clay from soil. Use of sugarcane baggasse ash as raw material favors cleaner production. As baggasse ash is waste which comes from boiler and we used it as a main raw material. By production of eco- friendly brick we can control land pollution and protect fertile layer of soil. Our aim is to modify and solve the problems occurring in conventional brick by our eco-friendly brick.

13. Environment Audit

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Environmental audit is a growth area which has received little attention in the auditing literature. There is currently mandatory requirement for companies to undergo environmental audit, although pressures on them to do so are growing, and there are some generally accepted standards regulating the nature of audit work. The 'Environmental Audit' is an initial step towards the pursuit of environmental quality management. The information gained from environmental audits can be used to facilitate and enhance environmental management from the single facility level to the national and international levels. Here we included two sections: section one examines environmental audits at the facility/company level and two discusses environmental audit characteristics, trends, and driving forces not commonly found in the available literature. These are used to help improve existing human activities, with the aim of reducing the adverse effects of these activities on the environment.

14. Application of Cleaner Production in Design and Simulation study of Modified Sulphonation Process.

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The biggest problem the dyestuff industries are facing today is of the waste- spent acid which is generated during the production process of dyes. It cannot be dumped or disposed as the

same is harmful to Human Life, and damage the Bio Diversity of the universe, also to comply the disposal norms of the hazardous materials. It needs to be treated by the industry based on the specific parameters given by the Pollution Control Board before disposing or can be given to Effluent Treatment Plant or Sulphuric Acid Regeneration Plant to make it appropriate for reusing it for the same process or using it for other processes depending upon its concentration procured. Using it for the same process may sometimes be a costly one because of its treatment therefore using it for processes like making gypsum for cement manufacturing is generally practiced by these industries. The aim of our project is to minimize the production of spent acid by using remedy instead of Oleum thereby adhering to the concept of CLEANER PRODUCTION. This project aims at minimizing the problem of spent acid in the production of reactive turquoise blue dye right at its source. The design and fabrication of the reactor has been completed successfully.

15. Cleaner production implication in optimization of HYCO Plant.

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Hydrogen production is conventionally done by Gasification of oil. But last few years, due to rising in oil prices globally so that world wild stem reforming process increases. The HYCO plant uses the natural gas as a feed for production of Hydrogen for making syngas via using the Steam Methane Reforming Process. In This process, we have different part for the optimization. To optimization HYCO plant we have change in steam to carbon ratio for increase efficiency of plant and give high conversion. Other opportunity to optimization is that HP steam converted in to lp steam and plant make a self-sufficient. Optimization of CO_2 compressor for energy consumption. In order to reduce the heat recovery of the Syngas Generation Plant, several modifications are suggested under this project. The thermal efficiency limit of the SMR (steam methane reforming) process is basis of energy balance.

An analytical solution for the process efficiency limit is derived from energy balance across the composite heat exchange curves. The solution can be used to calculate the process efficiency limit for each given set of reaction and process conditions of steam reforming process.

16. Air Quality Monitoring in Industries

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World's large population lives in urban area. In India, development of industry in different sector is increasing rapidly. During the last two decades, chemical industry and its pollution rate increases rapidly which results extremely high volume generation of air pollutants in different states of India. The large consumption of energy in various forms (e.g. fossil fuels, and bio-fuels) contributes to high levels of air pollution in industrial area and residential area. In many cities of India concentration of air pollution is very high which can causes the adverse effect on human health and also damage the environment and our properties. The human health effects include difficulty in breathing, wheezing, coughing and aggravation of existing respiratory and cardiac conditions. Therefore, Central Pollution Control Board (CPCB) is predetermined the air pollutants concentration level. Objective of this study is to introduce different parameters present in air and it's monitoring by analysis of solid and gaseous air pollutants in environment.

17. Hazardous Waste Management of Chemicals and Risk Assessment in Chemical Industries

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Hazardous waste management plays an important role in chemical industries. Many industries handle hazardous chemicals into the plant and it must be handled very carefully and stations must be assigned to handle these chemicals like input station, sub-station and output station. Safety parameters are also considered while handling these chemicals and by proper handling of these hazardous chemicals chances of accidents are less. Risk assessment is the study to assess the risks which may happen in the plant and it must be recognized before installation of plant. By keeping the regulatory norms of risk assessment one should asses it before installation of the plant. Proper installation of machineries and how it should be installed in a proper way is known by assessing risk assessment.

18. Comparison of dry and wet grinding of coal for cleaner fuel

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Grinding is an operation where only 4-5 % energy goes to new surface creation rest gets wasted in noise and heat generation. Coal is grinded in almost every industry for efficient combustion to generate power for different operations. During dry grinding of coal, large amount of dust is created and cyclone separators are required with grinding machine for particulates removal. Dry grinding generates less small particles size than wet grinding as per literature available. The present work discusses a systematic experimental as well as modeling of experimental values. To grind coal particles initially 7-10 cm of coal particles were used. Lab scale ball mill was used for both type of grinding. There were five different

parameters chosen to find the best possible combinations namely: amount of feed, ball mill rotational speed, grinding time, number of metal balls and amount of water. In wet grinding dust of particulates were not observed. Smaller particles size with wet drying was observed than dry grinding. It is concluded that adopting wet grinding may reduce air contamination in a significant amount.

19. Preparation of Activated Carbon from Coconut Shell

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Water treatment technologies in the developing world typically focus on removing two types of impurities from water sources: suspended solids and microbial pathogens. However, as industrialization and high-input agriculture has expanded into the developing world, chemical impurities such as pesticides, herbicides, and fertilizers have found their way into drinking water supplies and have been linked to severe health-related issues. Activated carbon has the capacity to remove these problematic chemicals from water sources. A simple, inexpensive, and effective activated carbon production process using local agricultural waste byproducts like Coconut shell was produced, and various chemical activation techniques were investigated by using salt. The adsorption capacity of chemically activated coconut shell charcoals was analyzed, with the help of industrial sample.

20. Bio-Scrubbing System to Curb Air Pollution

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Increasing carbon dioxide emission into the atmosphere, from fossil fuel combustion and other anthropogenic activities, has forced us to source for more sustainable and economical routes. Instead of developing new chemical catalysts and carbon dioxide-based chemistry, we should perhaps learn from nature. Over the past billions of years, Nature has evolved sophisticated mechanisms for carbon concentration, fixation and utilization, manifested through autotrophy. So here we try to design to assimilate carbon dioxide and reduce air pollution by developing a Portable scrubbing system which used biologically friendly adsorbent in combination with conventional adsorbents.

21. Spurrite Ring Formation in Cement Kilns

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Report deals with the kiln operations and critical studies of various parameters. Optimum process conditions and design considerations for cement rotary kiln plus new simulation techniques are part of this report. Cement rotary kilns form Spurrite ring and balls at regular intervals of time. Although creative solutions, including use of the 04 gauge shotgun kept in a certain cement plant's control room, have been devised for their elimination such rings and balls frequently grow without bound. The second option is to optimize the Pyro process and kiln design. The next option is to vary the burner and flame parameters with a controlled check on sulphur content of the burner fuel. Raw material is fed into an inclined rotating kiln and heated by counter current gas flow. Chemical reactions take place in the bed of raw material as well as in the gas phase. Heat and mass transfer between the bed and the gas phase are implemented. Also the heat transfer to the environment is taken into account. As a benchmark, the process of limestone calcinations is chosen. Results are compared with computational fluid dynamic simulations. The study includes developing and combining the models of gas-solid flow, modeling of pulverized coal combustion and heat transfer from flue

gas to the reacting mass and surroundings. The computational models predict the impacts of swirled angle of multi-channel coal burner on flame profile, temperature distribution and species concentration studies showed that lower guide vane angle as compared to the existing one result in more intense flame at the center.

22. Design and development of chemical looping combustion process – A clean energy generation initiative

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In this work it is aimed to conduct the systematic design and development of chemical looping Combustion (CLC) process of the available literature data. The generation of clean energy i.e. syngas depends on the various process parameters viz. bed height of the fluidized bed, amount of the catalyst, catalyst bed height, inflow rates of the influents etc. In this work, step by step methodology is adapted to serve a cleaner technology with the help of experimentation and modeling and simulations approach. The modeling and simulation approach felicitates the user friendly technique that minimizes the Resource cost and time which is of prime importance. Thus, in order to visualize the process i.e. thermo dynamical and thermo-chemical aspects of the chemical looping combustion; an optimistic approach for the CLC process is proposed.

23. A Study of feasible alternatives of Plate & Frame Heat Exchanger of DHDS plant.

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The DHDS plant operating at maximum throughput is hydro-treating Diesel to "EURO-IV Grade Diesel" having Sulphur content less than 10 ppm. The feed processed in plant are of two parts, hot and cold feed. The cold stream is incorporated in a Plate and Frame heat exchanger that exchanges heat with Dryer bottom product. But due to problem of leakage in the weld joints, choking of plates the exchanger is at standby mode.So, for the project work it is planned to analyze various process alternatives which can replace the existing design, viz. Designing of Shell and Tube heat exchanger, analyzing the existing Plate and Frame heat exchanger and many other alternatives feasible for the DHDS process.

24. Determination of thermodynamic properties of green solvent using ebulliometer.

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An ebulliometer is intended to precisely quantify the breaking point of fluids by measuring the temperature of the vapor-fluid balance either isobaric ally or isothermally. The essential parts in a Swieto slawski ebulliometer, which works isobarically, are the kettle, the Cottrell pumps, the thermo well, and the condenser. Such an ebulliometer can be utilized for to great degree precise estimations of bubbling temperature, sub-atomic weights, common solubility, and dissolvable purities by utilizing a resistance thermometer (RTD) to quantify the close balance states of the thermo well. Solvents characterize a noteworthy part of the natural execution of procedures in substance industry furthermore effect on cost, wellbeing and wellbeing issues. A "Green" solvent communicates the objective to minimize the natural effect coming about because of the utilization of solvents in connection with present generation.

25. Metal Recovery Studies from Spent Catalysts

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One of the major aspects of chemical engineering is to recycle and reutilize the ever-growing industrial wastes. Talking with respect to the petrochemical industries, there are a wide variety of catalysts being used in various processes. Catalysts used in Hydro treating, fluid catalytic cracking, hydro cracking and isomerization etc represent a large proportion of the total catalyst market. This huge demand also leads to the creation of a large amount of spent catalyst wastes, which is of huge concern worldwide. Our Present work includes the study, recovery as well as the characterization of metals recovered from spent catalysts.

26. Pyrolysis of waste tires to fuel oil.

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The standard of living, quality of life and development of a nation depend on its per capita energy consumption. Global energy supply that mainly depends on fossil fuel is decreasing day by day. Pyrolysis and combustion behaviors of a single waste tire will be investigate. The influence of temp (350℃-400℃) and without oxygen content in gas on combustion behavior of tire samples and solid products of pyrolysis process will be studying. The primary objectives of this work will be to demonstrate the conversion of scrap tires to TPO (Tire Pyrolysis Oil) purification method distillation, liquefaction, adsorption, incineration etc

methods will be study for TPO purification. The analysis describes proximate and ultimate analysis and different parameters of oil will be investigated. At the end it will be study that it will be possible to use scrap tire pyrolysis oil in fuel engines by comparing the property of TPO and purified fuel oil with diesel, in future using tire.

27. Recovery of precious metals from E- Waste

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Electrical and the electronics equipments play an important role in our day to day life. Technology changes in a short span of time and today's equipments become tomorrow's waste. India, being the 5th largest producer of E-waste needs a proper technology regarding proper recycling of useful and precious metals as well as the management of hazardous components in E- wastes. Recovery of heavy metals from E-wastes had been a major area of research since last few years. But looking towards the recycling scenario of Precious metals (Ag, Au &Pt), India still don't have a well-known Eco friendly technology in this regard. In the present study, an attempt is made to recover precious metals from E-waste considering the factors like product purity and its ecofriendly aspects. This study is equally beneficial for E-waste recycling sectors as well as for precious metal refining sectors and it can also be a boost to catalyst manufacturing sectors as metals obtained can be used further for catalyst preparation in various chemical processes.

28. Use of distiller waste of soda ash plant as an adsorbent for treatment of effluent from dyes industries

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Solid waste from the distiller waste, which is a by-product of ammonia-soda process (Solvay method) for the production of soda ash has been used as an alternative adsorbent for removing the dyes from waste water. This will reduce the solid waste disposal quantity of soda ash plant and simultaneously will treat effluent of dyes industry. The waste of soda ash contains NaCl, $CaCO_3$, $CaSO_4$ and $Ca(OH)_2$ which creates very huge problem in ammonia-soda plant. Adsorption is an effective process for the removal of dyes from effluents of dyes industries. This study includes the adsorption of dyes on solid waste of soda ash plant.

29. A study on stability of Pickering emulsion.

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Emulsion stabilized with solid particles called Pickering emulsion. Solid particles can stabilize oil in water or water in oil emulsion.

30. Energy conservation in soda ash plant

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Saving in energy and energy related cost are given for many energy efficiency measure base case study data in soda ash production reduce energy consumption in cost effective manner while maintaining quality of the product manufactured.

31. Increase solvent recovery in pharmaceutical industry

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Increase solvent recovery (isopropyl alcohol) in production of atorvastatin calcium by using of different type of unit operation like distillation, sedimentation, extraction, etc.

32. Polymer memory

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Polymer Memory is new technology that uses conductive polymers of silicon-based construction to store information. Crystalline substance is used in polymer memory. And storage space changes between layers of polymer. It's cheaper than existing circuit.

33. Recovery of Precious Metal from Hydro processing Spent Catalyst.

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The purpose of making of this project is recovery of precious metal from hydro processing spent catalyst. By this we less price of product which produce from petroleum industry and with that we control pollution which make by this spent catalyst.

34. To use ceramic waste as a construction aggregation.

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In ceramic industry out of 100 %, 30 % is waste; there are many source of pollution or waste like liquid waste with color or dye, clay, flash par and other material present in water. Solid waste like fired & unfired broken tile, wash basin and toilet. As well as ash from blast furnace and other solid waste. Hence we require giving solution of this waste because it produces a problem in ground water also due to land filling it cause problem. That's why we give solution of this problem; we use liquid and solid waste in making strengthen cement as well as concrete. We use ash also in cement because it provides its strengthening property to cement. So for solution we first do crushing of all material in jaw crusher, then we screens it and fine particle we use in cement or in concrete. And coarse particle we use as a raw material of road block manufacturing &also we are able use fine particle as a raw material with clay to form object of clay. After it we add some material to give strength to every object.

35. Use a bentonite as an adsorbent to remove Methylene blue from waste water.

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Methylene blue creates pollution in water by entering in waste water through chemical reactions. So, we want to show the process of removal of Methylene blue from waste water which is generated in JAYSHREE PVT.LTD.

36. Heat Recovery in Distillation Column

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Distillation is one of the most extensively used processes in a wide range of industries especially in the energy sector. It is important to reduce the energy consumption of the distillation. This work proposed a process to recover the energy from exit streams during the distillation process of three Consecutive columns. There are several novel techniques to recover the heat with the distillation system; however, a complex control system is required. This work proposed a simpler technique by exchanging the heat between streams without interrupting the internal distillation process that might cause a serious control system. The proposed process is executed by using heat exchanger network with pinch analysis to maximize the process heat recovery. Therefore, we proved the recovery of heat from exit streams from distillation process is to be effective for energy saving.

37. Utilization of Sugarcane Baggasse for dye removal

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The literature reviewed revealed that there has been a high increase in production and utilization of pollutants in last few decades resulting in a big threat of pollution. Efficient techniques for the removal of highly toxic compounds from water and wastewater have drawn significant interest. Adsorption is recognized as an effective and low cost technique for the removal of pollutants from water and wastewater, and produce high-quality treated effluent. In the present work an adsorbent sugarcane baggasse (SB) was used for the adsorption of brilliant green from dilute aqueous solution. Batch experiments were carried out to evaluate the effect of parameters like adsorbent dosage, time and concentration of the

adsorbate. Langmuir and freundlich models were applied to the system. The Langmuir adsorption capacity was found to be 19.53 mg/g. These results show clearly the efficiency of SB as a low-cost solution for removal of brilliant green from aqueous solution.

B.E./B.Tech (Environmental Engineering)

1. Integrated Solid Waste Management

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With the emerging concern on large quantity of the waste being produced both in the form of solid and liquid waste, the concept of waste management becomes one of the key focus of sustainable development principles which is based on policies, and practices that are resource-conserving, follow standards that can be met in the long term, and respect values of equity in human access to resources. Managing waste can be challenging for industrial, commercial and institutional sectors. Organization must deal with wide variety of material large volume of waste, and behavior of many customers, visitors and students from within and outside of the province. However, a strategic solid waste resource management planning approach will help to define solid solution.

2. Utilization of Municipal Solid Waste as a Fuel in Boiler and Furnace

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Conventional fuel used at present are limited in quantity and the use of this fuel is hazardous to Environment. In option to conventional fuel, Refused Derived Fuel could be used. In this project, municipal solid waste was collected from a landfill site and was kept for drying for 7296 Hours. Plastic and metals were segregated manually and the remaining waste was grinded. Pallets were made by compressing the wastes in palletalisationmachine.RDF from MSW could also be used in ovens, boilers etc. The result shows that the efficiency of pellets is almost the same as coal. The major advantage of RDF is that the emission of pollutants from it is lesser compared to conventional fuel.

3. Design of push-pull system in pickling tank for cold rolling mill

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Our topic is regarding air pollution. We have discussed about pollution due to highly acidic compounds in pickling tanks at cold rolling mill and its desired solution also being discussed. Highly acidic gases are generated through oxidation process between concentrated acids (sulphuric acid, fluoric acid, nitric acid, hydrochloric acid etc.) and raw metals got out from earth crust. An emitted gas goes upward in the hood system and then is thrown into atmosphere with the help of duct. According to old process, during cleaning process of the tanks the workers of particular industries would have to enter in tanks and cleaned it with the help of corrosion removal equipment so it’s difficult to removed corrosive material in highly acidic tanks and it’s also dangerous for the workers, so nowadays new push-pull system is being developed to reduce the ill health effects and indirectly air pollution.

A full-scale installation which simulates a surface treatment tank provided with a push-pull ventilation system has been designed. This study examines the influence of the geometry of

the push element on the capture efficiency of the system, here, We have applied nozzles and manifolds with high velocity and pressure at the edge of tank instead of providing fan to generate push jet which carries fumes generated as a result of redox process between the impure meal ore chips and concentrated acid with which tank is fulfilled, to the hood in laminar flow and increase the efficiency of the ventilation system.

4. Studies on the efficacy of sewage sludge from STP (Rajkot) used as organic manure as compare to chemical fertilizers. Our plant of experiment is Cowpea [Vignaunguiculata (L)].

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The management of municipal solid waste has become a severe problem due to enhanced economic activities and rapid urbanization. To prevent this problem in Rajkot city we have decided to convert MSW into organic manure. Land application of MSW can reduce the sludge disposal cost of sewage treatment and a large part of the Nitrogen, Phosphorus and organic matter of crops. By Plantation of a single plant with the different concentrated organic manure the efficacy of organic manure was checked which concentration of manure would be preferable for the plantation in field.

5. Engineered In-situ Aerobic Destruction of Organic Pollutants

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Gujarat having the longest coastline in the country, sea water intrusion into aquifers is a common problem all across Gujarat right from Kutch and Saurashtra to Vadodara and Valsad. Aquifers in Gujarat are beset with numerous quality problems, some of which are increasing intensity over the years. Groundwater pollution in Gujarat is due to agricultural activities, street drainages, sewage landfills, industrial discharges, spills, vehicular emissions fall out etc. The CETP effluents are directly discharged in earthen drains which finally meet the estuarine of the rivers like Narmada which lead to groundwater contamination. Gujarat is facing organic and inorganic groundwater contamination problems. Enough studies and research have been carried out on inorganic contaminants, and its treatment techniques have been found. Our research majorly focuses on the real time problem of the organic contamination present in groundwater; As very minimal research have been done on it and thus providing a solution to it.

6. Physico-chemical characterization of soil and ground water affected by Textile Effluent at Jetpur.

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Incessant growth of textile industries are making life easy and comfortable but at the same time creating several geo-environmental (i.e., soil and ground water) issues. Keeping this in view, study was performed on textile town, Jetpur in Rajkot district of Gujarat. These effluents are containing several hazardous organic and inorganic substances. However, these small-scale industries are not able to utilized scientific treatment methodology and disposing the effluent either nearby ground or in river which severely impacts soil and water reservoirs (surface and ground water) quality. Therefore, it is mandatory to determine physical, chemical and biological properties of soil nearby area of Jetpur (in agricultural region) and the ground water used for irrigation. In present study the effluent from an industry, ground water quality, and contaminated soil affected from effluent and virgin soil (not affected from effluent) would be characterized and get compared with Indian Standards. Later, possible

recommendation or treatment process would be given to the industries before they discharge effluent into geo-environment.

7. Solar photo-catalytic degradation of wastewater using parabolic trough reactor

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In recent years, photo-catalytic oxidation processes with ultra violet (UV) radiation and semiconductor photo-catalyst have gained immense research interest as an effective wastewater purification method because of its efficacy in decomposing and mineralizing the hazardous organic pollutants as well as the opportunity of utilizing the solar UV spectrum. Parabolic-trough collectors use mirrored surfaces curved in a linearly extended parabolic shape to focus sunlight on a absorber tube running the length of the trough. The project will include degradation of industrial waste water, design of parabolic trough reactor & study of factors affecting the process like natural light source, pH, temperature, catalyst loading, contaminant concentration, etc

8. Microbial consortium for degradation of organic waste

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The waste can be solid, liquid or gaseous. Solid waste includes Biodegradable and Non-biodegradable waste. In order to treat biodegradable waste, microbial population can be used, mostly in the bioremediation process. As the microbial consortium is two or more microbial groups living symbiotically, so it becomes easy to degrade different types of organic waste. The degradation of organic waste by microbial consortia is highly significant, it reduces time

span of degradation and produces no foul odor. Presently degradation of waste is very difficult. To degrade this waste we use chemicals which can degrade all types of waste quickly, but these chemicals leads to different types of pollution like land pollution, ground water pollution and soil pollution which harm our environment and all types of living organisms. So to reduce such types of pollution we can use a different way to degrade organic waste by using microbial consortium.

9. Effect of Settling Time and pH on the Treatment of Domestic Grey Water using Mango Seeds as Coagulant

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Grey water is all wastewater generated without fecal contamination. The grey water sample was collected from a residential society in Ahmedabad and the natural coagulant used was freely available Mangifera indica (Mango) seeds. Turbidity and COD were analysed for different concentrations of coagulant dosage and by varying the settling time and pH. The initial characteristics of the grey water were assessed based on the parameters pH, TS, TDS, Turbidity, COD and measured to be 7.4, 955 mg/l, 670 mg/l, 231 NTU and 698 mg/l respectively. Optimum removal was observed at 20 mg/L of coagulant dosage resulting in 78% removal of turbidity and COD, respectively at 60 min settling time and pH 9. The settling time was varied from 20 to 60 min, and pH was varied from 4 to 9 considering the removal of micro-flocks. The study concluded that the settling time does not affect the removal efficiency of turbidity and COD from grey water using mango seed as natural coagulant. The present study focuses on the development of a decentralized grey water treatment unit comprising of natural coagulants to ensure the reuse standard.

10. Assessment of Water Quality Index for Deesa City, Gujarat

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Water is a natural resource, it should be assessed regularly and people should be made aware of the quality of drinking water. The present study is aimed at assessing the water quality index (WQI) for the Deesa city. This has been determined by collecting samples and subjecting samples to a comprehensive physicochemical analysis. For calculating WQI, the following 11 parameters have been considered: pH, total hardness, calcium, magnesium, chloride, free chloride, Bicarbonate, nitrate, total dissolved solids, iron, and fluorides. The results of analysis have been used to suggest models for predicting water quality. The overall water quality index (WQI) for Deesa city was obtain 61.61which falls in poor quality status which reveals that the water needs some degree of treatment before consumption.

11. Treatment of Sewage Water for Use in Irrigation

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Climate change and the subsequent change in agricultural conditions increase the vulnerability of agricultural water use. Wastewater reuse is a common practice around the globe and is considered as an alternative water resource in a changing agricultural environment. Due to rapid urbanization, indirect wastewater reuse, which is the type of agricultural wastewater reuse that is predominantly practiced, will increase, and this can cause issues of unplanned reuse. Therefore, water quality standards are needed for the safe and sustainable practice of indirect wastewater reuse in agriculture. Reduction of pollutants in the sewage water down to permissible concentrations is necessary for the protection of ground water and the environment. Characteristics of the sewage water generate need to be found out with reference to the following parameters; temperature, pH, Total Dissolved Solids (TDS), Chemical oxygen demand(COD), Biological Oxygen Demand (BOD), and

Suspended Solids (SS). Samples are collected from raw sewage water, treated sewage water outlet to evaluate the performance of Aeration and ASP.

12. Performance Evaluation of the UASB Reactor plant in Banas Dairy

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UASB reactor works on gas-liquid-solids separator (glass) principle that is it separates the gas from the treated wastewater and the sludge .This is a single tank process in an anaerobic centralized or decentralized industrial wastewater or black water treatment system achieving high removal of organic pollutants. Wastewater enters the reactor from the bottom, and flows upward. A suspended sludge blanket filters and treats the wastewater as the wastewater flows through it. Bacteria living in the sludge break down organic matter by anaerobic digestion, transforming it into biogas. Solids are also retained by a filtration effect of the blanket. The up flow regime and the motion of the gas bubbles allow mixing without mechanical assistance. Baffles at the top of the reactor allow gases to escape and prevent an outflow of the sludge blanket. As all aerobic treatments, UASB require a post-treatment to remove pathogens, but due to a low removal of nutrients, the effluent water as well as the stabilized sludge can be used in agriculture.

• In Banas dairy, three UASB Reactors are design of each reactor capacity - 1600 LLPD.
• In Banas dairy they use cow dung as a blanket inside the UASB reactor that is acts as a charger for anaerobic digestion of thickness of 4 to 5 meter.

13. Various pre-treatment technologies for bio ethanol production

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Due to increase in population and industrialization, all over the globe the demand for fossil based fuel is constantly increasing. This increase in demand for non-renewable fossil based fuel is exhausting the reservoirs of oil as well as possesses severe threats to environment. Thus energy sector have shifted its focus from non-renewable fossil based fuel to renewable bio fuels like biogas, bio ethanol, biodiesel, etc., contributing towards sustainable development and overcome the threats to environment. Among these bio fuels, bio ethanol is substituting source of energy receiving special attention over the globe due to exhaustion of non-renewable fossil fuels and has some significant advantages such as its capability to replace gasoline, to achieve the carbon emission goals under Kyoto Protocol and can be used as transportation fuel with minimal or no modifications in the existing vehicular engines. This bio ethanol is produced using lingo cellulosic materials and biomass like municipal solid waste, crops, etc. But crops cannot meet the global requirements of bio ethanol production considering food v/s fuel debate. So, the lingo cellulosic substances such as agricultural wastes, kitchen waste, municipal solid waste etc., are captivating raw material for bio ethanol production. Agricultural wastes and kitchen wastes are not only cost effective but are also renewable and ample in quantity. Bio ethanol from lingo cellulosic material could be a promising technology though the process has several provocations and limitations such as handling and transport of the biomass and coherent pre-treatment methods for total delignification of lingo cellulosic materials. Concentrations of fermentable sugars after enzymatic saccharification or enzymatic hydrolysis can be increased by considering appropriate pre-treatment methods, also improving the efficiency of the process. Converting glucose as well as xylose to bio-ethanol needs some new technologies, to make the whole process cost effective. This paper reviews various pre-treatment methods available for lingo cellulosic materials to be further hydrolyzed and fermented to produce bio ethanol.

14. A Zero Liquid Discharge in Pharmaceutical Industry

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Zero Liquid Discharge (ZLD) is an ideal situation of complete closed loop cycle, where discharge of any liquid effluent is eliminated. Analysis of major characteristics of all influent streams entering into ETP, Identification of potentially recyclable streams and highly polluted stream, Segregation of streams on the basis of their characteristics and applicability of 4R (Reduce, Reuse, Recycle and Recover) principle in particular plant. Optimization of Effluent Treatment Plant (ETP), RO Plant and Multi Effect Evaporator (MEE) plant. The industry, for which we are working on ZLD, is basically a chemical industry discharging waste water is 370 m3 /day. To achieve ZLD, this huge discharge can be eliminated and daily water consumption of industry can be reduced significantly. The effluent coming to ETP is having some significant effluent characteristics like widely varying pH, high COD and Ammonical nitrogen. After primary, secondary and tertiary treatment, the effluent meeting discharge norms is send to FETP of NCTL for further treatment and disposal. In this project an attempt would be made to optimize the dose of chemicals added etc. would also be done during the course of the project. Applicability and feasibility study of different techniques like: ultra-filtration, reverse osmosis, different type of evaporator etc. would also be done in later stage of project. Based on all studies and results of experiments, methodology would be suggested to achieve ZLD in given industry.

15. Removal of heavy metal by using hatchery residual bio sorbent

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Water is essential to all forms of life and makes up 50-96 % of the weight of all plants and animals. In recent years pollution of aquatic environment by heavy metals has increased. The continuous mixing of industrial effluents containing heavy metals to the natural resources

deposits the toxicity in natural water resources. Due to their potential toxic effect and ability to bioaccumilate it is very difficult to remove from wastewater stream. The potential sources of the heavy metals are industries, mining, and agriculture. The most commonly witnessed heavy metals in industrial wastewater are Arsenic, Lead, Mercury, Cadmium Chromium, Copper, Nickel, and Zinc. Despite of use of suitable conventional chemical treatment processes for the removal of heavy metals, the effluent after treatment contain too high concentration of heavy metals. In order to trouble shoot the problems of conventional chemical treatment various bio sorbents such as eggshells, microalgae and banana peels can be adopted as supplement to conventional treatment.

16. Removal of heavy metals from leachate by physical and biological treatment

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Heavy metal pollution is one of the major pollution in today's world. The aim of the study is to remove heavy metals based on the treatment method applied to leachate from a municipal waste landfill i.e. BEIL situated in Ankleshwar. As there were many issues related to presence of heavy metals in this industry, we have decided to take IDP based project to remove heavy metals from leachate. The sources of heavy metals in leachate are industrial waste, municipal waste and much other waste. The highest concentrations of heavy metals found in leachate are from young landfills in the acid fermentation phase and at very low pH.The pH becomes neutral and there is decrease in concentration of heavy metals due to solubility at both maturation and stabilization phases. Heavy metals such as zinc, lead, cadmium and nickel are present in relatively high concentration at landfill site. This treatment includes two processes: (i) Physical (ii) Biological. The physical treatment includes removal of heavy metals by filtration mechanism using low cost orange and banana peels. The biological treatment includes various bacteria for removal of heavy metals. It is a comparative study of both the processes and can conclude the result.

17. To remove the toxicity from the wastewater by using microalgae

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Rigorous research works are going on in the field of wastewater treatment. The recent research of wastewater treatment by using microalgae is also proving more effective in removal of toxicity from wastewater. Microalgae are known to sequester toxic compound. Discharge of toxic pollutant to wastewater collection system has increased concurrently with increased in industrialization. Micro algae are efficient absorber of toxic compounds. Bioaccumulation of metals by use of algae can be feasible method for remediating wastewater contaminated with metals. It is established that marine and fresh water algae are capable of taking various toxic pollutants from wastewater and accumulate it in their cells. Algae are believed to be good accumulator of Zn. It can also accumulate the other heavy metals such as Cu (II), Pb (II) and Cr (III) as well as Ni (II), Cd (II), Co (II), Fe (II) and Mn (II). The living algal cell accumulate trace nutrient metals (such as Co, Mo, Cu, Mg, Zn, Cr, Pb and Se) intra cellular ally by active biological transport. This method of removing toxicity of wastewater by the use of microalgae is economical for removing toxic compound as well as some heavy metal, resulting in good quality of reusable effluents. Microalgae provide the solution for tertiary and quandary treatment, as it has an ability to use inorganic nitrogen and phosphorous for their growth. This is an environmentally sound alternative for the toxicity removal from wastewater.

18. Treatment of oily wastewater by electro coagulation

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Oil pollution in water usually comes in four states that are free oil, heavy oil, emulsified and dissolved oil, where the droplets are fully dispersed and not visible. Emulsified oil droplets are the most common in industrial oily wastewater and are extremely difficult to separate. The methodology for separating the oil is dependent on the oil droplet size. We are applying electro coagulation process by using aluminum, iron and combination of both electrodes for treatment the oily wastewater. The current density, initial pH, electro coagulation time will play an important role in decreasing the turbidity and increase oil removal from emulsion. This process will separate the oil from the oily wastewater as well as it is effective in the reduction of chemical oxygen demand.

19. HHO Dry cell Generator

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Today, the availability of fuel oil is increasingly limited and combustion results have impact on pollution of the environment. Then, all efforts to save fuel consumption and the green energy utilization of should be continued. One example of energy savings is utilizing HHO Gas (Brown's Gas) in Internal Combustion Engine (ICE). HHO generator is an efficient approach that used to increase the fuel efficiency in a combustion engine by increasing the energy produced per mole of fuel during the ignition process. Although people use HHO generators in practice a very little research has been carried out in implementing an efficient system. An efficient/optimal system is supposed to produce a large volume of hydroxy gas using a very little power. Therefore, such a system will be able to increase the power of a spark ignition engine while reducing the air pollution. The rapid depletion of fossil fuels and rising of oil prices has led to the search for Secondary fuels. The Secondary fuels that we are using should have the same efficiency or greater efficiency of the engine that uses ordinary fuel. In this project the secondary fuel used is HHO gas. HHO otherwise known as hydroxyl

or Browns Gas is the gas produced from splitting water into hydrogen and oxygen from electrolysis and allowing the gas to stay in a premixed state for use on-demand without the need for storage. This reduces the exhaust gas emitted during the working of engine, and the temperature of the engine is also reduced which is produced by the burning of ordinary fuels. The HHO gas is injected into the inlet manifold of the combustion chamber through the air filter of the engine. From this design the fuel utility is reduced from 10% to 30% which minimizes the carbon deposition in the cylinder thereby increasing the changing period of engine oil, it also improves the efficiency of the engine and the life span.

M.Sc. Environmental Science

1. Spot Garbage: Smartphone App to Detect Garbage

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Maintaining a clean and hygienic civic environment is an indispensable yet formidable task, especially in developing countries like India. With the aim of engaging citizens to track and report garbage in their neighborhoods, we present a novel smart phone app, called Spot Garbage, which detects and coarsely segments garbage regions in a user-clicked geo-tagged image.

2. General solid waste management

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Due to population upsurge and urbanization, solid waste management is now one of the chief issues to deal with as it affects quality of life. Ahmedabad is the 7th largest city of India and generates about 4000 Metric tons of waste daily. The studies reveal that this MSW comprises of more than 50% of organic waste in Indian context as it contains vegetable, food waste, animal dung, paper, cloth and other biodegradable components as well. This study aims at providing an overview of the stages of waste management i.e. Prevention, Reuse, Recycle, Energy recovery, Disposal and its composition at the Ahmedabad city level. It also provides a further insight of feasibility and aids of adopting segregation at source and decentralization of SWM in order to provide better future. Out of 4000 MT generated daily only 800 MT would be needed to dispose daily which would lead to 80% volume reduction then current scenario.

3. Treatability Studies of Waste Water with Checking Efficiency & Design of ETP, Process of MEE Technology, Safety and Cleaner Production with Sustainable Development in Macleod's Pharmaceutical Ltd; Sarigam; Vapi

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Rapid growth of Industrialization has not only enhanced the productivity but also resulted in the production and release of toxic substances into the environment. The Study Start with Cleaner technology to minimize the waste from Source with suitable cleaner tools. Cleaner production, on the other hand, directs activities towards every aspect in plant, particularly within the all manufacturing sector but every industry generated waste. In this topic to find out what type of cleaner tools is most cost beneficial in pharmaceutical industry. The study in end of pipe treatment checks efficiency and adequacy. The study start with waste water treatability parameter of COD, BOD, Ammonical nitrogen, chloride, TDS, TSS, TOC, and Heavy metal content in wastewater generated from chemical solvent based Pharmaceutical industry poses a major threat to the environment. The generation of waste water is treated that type of suitable design making of ETP plant. The study of high COD water treatment with MEE technology was done in pharmaceutical industry. In this study area Safety and sustainable development also consider. In the parameter of safety every step in the industrial

safety is needed & our responsibility to every worker is safe in Industrial environment. In this study, what type of PPE needed to the worker in particular workplace area &what type of safety procedure follow to any work maintenance these are cover in safety section. The all study to be considered every impact towards the future generation to make Sustainable development.

4. Cleaner Technology Assessment with Physico-Chemical characterization of Wastewater for Coromandel Ltd, Ankleshwar.

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The present study focuses on the pollution reduction at source by Cleaner Production and Cleaner Technology methods for **pollution control and minimization at source** and **pollution monitoring** with detailed analysis by **Physico-Chemical characterization study**. The study incorporates detail study of troubleshooting **study of ETP with foaming studies focusing on the Secondary Aeration Tank** and the other water Treatment Technologies such as Multi Effective Evaporator, Fenton treatment, treatability study of Secondary Aeration tank etc.

5. To check growth of Zea Mays and Vignamungo with use of Dairy Sludge instead of fertilizer

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The aim of this study was to assess the efficacy of dairy sludge as a fertilizer and to evaluate the leaching of its nutrients. The sludge was applied to pots containing cultivated soil and sludge in ratio of 25%, 50%, 75% and 100% which used a completely randomize design. The

highest growths of maize and black gram are in 75% ratio soil and sludge. The height of the plant was measure at 15 day interval time. The chemical property of sludge also performed. Sulphate, phosphorous, chloride, Nitrogen is highest amount than soil. Thus it may conclude that Dairy sludge is used as fertilizer purpose.

6. Zero Waste Implementation plan in Hem chandracharya North Gujarat University Campus, Patan

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The study of Zero waste implementation plan in HNG University campus, Patan discusses the importance of waste stream analysis with special reference to the academic waste to design and develop sustainable solid waste management system in HNG University. In this study the solid waste was segregated into Dry and Wet Wastes. Dry wastes were classified into 7 primary categories, which were further classified into a total of 23 sub-categories. Waste stream analysis was carried out among all Departments, Buildings and canteens. The result shows that the average SW generation rate of each Department is 1.80±2.18kg/day. The study found that wet waste contribute 36%of overall solid waste stream that can be recovered as good quality compost. Components in dry waste shows that metal and glass wastes are 100% recyclable while paper and plastic have the recovery potential of 98% and 94% respectively. The study has shown that 99% Solid Waste of HNGU campus could be recovered through source segregation, segregated collection, composting and recycling practices. The study have suggested programs and policies for improving source segregation, storage of recyclables, collection, transportation and safe disposal methods to increase recovery rate towards framing Sustainable Solid Waste Management System.

7. Solar energy storage using hydrated salts

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India has abundance of solar radiations with about 3750+ clear, sunny hours in a year. India's theoretically calculated solar energy incidence on its land area alone is about 5000 trillion kilowatt-hours (kWh) per year. The solar energy available in a year exceeds the possible energy output of all fossil fuel energy reserves in India. Because of the Tropic of cancer and Equator, there exists a prime geographical advantage when it comes to daylight; India has an average annual temperature that ranges from 25°C–32°C, indicating that India has great solar potential.

Solar energy storage through thermal energy storage has received increasing attention because of its high potential and need for effective and sustainable energy use. However, the most common problem in solar power generation plants is the existing gap or time lapse between availability of daylight units (KWh) and its period of usage. Latent heat thermal energy storage is one of the most efficient ways of preserving thermal energy which the difference between energy production and consumption can be solved. Moreover, the advantages of Phase Change Materials (PCMs) will also induce high energy storage density and isothermal nature of the storage process. Phase Change Materials play a significant role in reducing the size and volumetric capacity of storage. This research paper summarizes a detailed investigation and analysis of the hydrated salts and their use in enhancing the facility of storing thermal energy.

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