Biohydrogen production/Biofuels:

Funding details:

Ramalingaswami re-entry Project:

Principle Investigator: Dr. Sudheer Pamidimarri

Funding agency: DBT-India

Starting data: August 2019

Project title Hydrogen gas production by engineered Escherichia coli utilizing crude glycerol and lignocellulosic biomass

Funding amount: 113.6 Lakhs [5 Years].

Expected outcome:

- The project is intended to develop zero-emission strategy for the production of green fuel (H_2).
- Waste biomass will be utilized to produce H_2 fuel.
- Low cost fuel production can reduce the cost of H_2 production up to 40-fold compared to present commercial value.
- Metabolic flux engineering technology intended to develop will have application in production of many industrially important chemicals.

Industrial project

Project title: Designing and fabrication of facile molecular systems for synthesizing stable bioactive peptides/proteins with pharmaceutical significance derived from green algae and marine biota.

Principle Investigator: Dr. Sushma Chauhan

Funding amount: 3,60,000 Rs.

Expected Outcome:

- Aims to identify novel bioactive peptides/proteins having pharmaceutical significance from marine biota.
- Genetic engineering technology for the synthesis of antimicrobial peptides will be developed.
- A technology for the development of stabilized peptides by backbone cyclization is proposed to develop in this study.

Funding via fellowship

DBT-JRF Fellowship: Tanushree Madavi

1st year : 31,000 + 16% HRA = 35,960 X 12 months = **4,31,520 Rs + 30,000 contingency**

2nd, 3rd and 4th year: 35,000+16% HRA = 40,600 X 12 months = **4,87,200 + 30,000 contingency**

Report:

Project title Hydrogen gas production by engineered Escherichia coli utilizing crude glycerol and lignocellulosic biomass

Hydrogen (H2) is considered as the cleanest energy since upon combustion H2 results in no carbon footprint is released to environment. Biological hydrogen is generated by the green process utilizing microbial fermentation process. H2 is clean energy credited with zero emotions and globally at present H2 is the most promising in the succession of fuel evolution, with several technical, socio-economic, and environmental benefits. H2 gas is safer to handle than domestic natural gas and is now universally accepted as an environmentally safe, renewable energy resource and an ideal alternative to fossil fuels. Microbial cell factories, unlike their chemical or electrochemical counterparts; H2 generation is catalyzed by microorganisms in an aqueous environment at the ambient temperature and atmospheric pressure is a complete green process. E. coli being an enteric bacterial species is naturally capable of producing low levels of hydrogen is a native microbial fuel cell for H2 production. The present study includes the development of engineered E. coli with fabricated metabolic flux-controlled system is forecast to have efficient H2 production which is a novel tool will replace physical knockout system with translational control gene silencing system. This will help in diverting metabolic flux rate towards H2 production. Moreover, this study will utilize the lignocellulosic biomass and crude glycerol generated during biodiesel production. In comprehensive prospective the total strategy will be carbon neutral and/or negative for the sustainable generation of biohydrogen (Figure 1). In this study we initiated the work with the physical knockout system for the production of the H2, and successfully enhanced H2 production in knockout E. coli. Designing and implementation of translation-controlled gene silencing is in under progress (Figure 2).

Publications:

1) Madavi, T.B., Chauhan, S., Jha, M., Choi, K.-Y. and Sudheer D.V.N.P*, Biohydrogen machinery: recent understandings, their genetic fabrication and future prospects. Chem. Eng. Technol (2021) In-press (IF: 1.74)
2) Pamidimarri DVN Sudheer, Sushma Chauhan, Wooyoung Jeon, Jung-Oh Ahn, Kwon-Young Choi, Monooxygenase-mediated cascade oxidation of fatty acids for production of biopolymer building block, Biomass Conversion and Biorefinery, (2021) (In press) (IF: 4.9)
3) Seo AP, Shashi KB, Hyun AP, Seo YK, Sudheer DVNP*, Yand Y-H, Chio KY*, Bacillus Subtilis as a robust host for biochemical utilizing biomass. Critical Review in Biotechnology (2021) 41,(6) 827-848 (IF: 8.2)
4) Sudheer DVNP*, Sushma Chauhan and Velramar B, Bio-hydrogen: technology developments in microbial fuel cells and their future prospects. Book title: Biotechnology for Biofuels: A Sustainable Green Energy, Edt. Nitish Kumar, (2020) Springer Nature, USA.
5) Sushma C, Velramar B, Soni RK, M Mishra M and Sudheer DVNP*, Biofuels: sources, modern technology developments and views on bioenergy management. Book title: Biotechnology for Biofuels: A Sustainable Green Energy, Edt. Nitish Kumar, (2020) Springer Nature, USA.
6) Sushma C, Balasubramanian V, Rakesh KS, Mohit M, Vargobi M, Tanushree Ba M, and Sudheer DVNP, Genetic Engineering and Fabrication of Microbial Cell System for Biohydrogen Production; Book title: Biohydrogen: Developments and Prospects; Chapter6, Edt. Sonil Nanda and Prakash Sarangi, (2021) Apple Accadamic Press, Taylor and Francis, UK. (In-press)
7) Sushma C, Balasubramanian V, Sneha K et al, Sudheer DVNP*, Engineered microbial systems for the production of fuels and industrially important chemicals, Biorefinary Advances: Production of Fuels and Platform Chemicals; Edt. Prakesh K.S. (2021) Wiley Scrivener Publishing LLC, US. (In-press)

Figure 1. Bio-hydrogen production by engineered *E. coli* from crude glycerol and lignocellulosic biomass. The schematic representation of carbon neutral/negative process for the production and utilization of bio-hydrogen as green fuel.

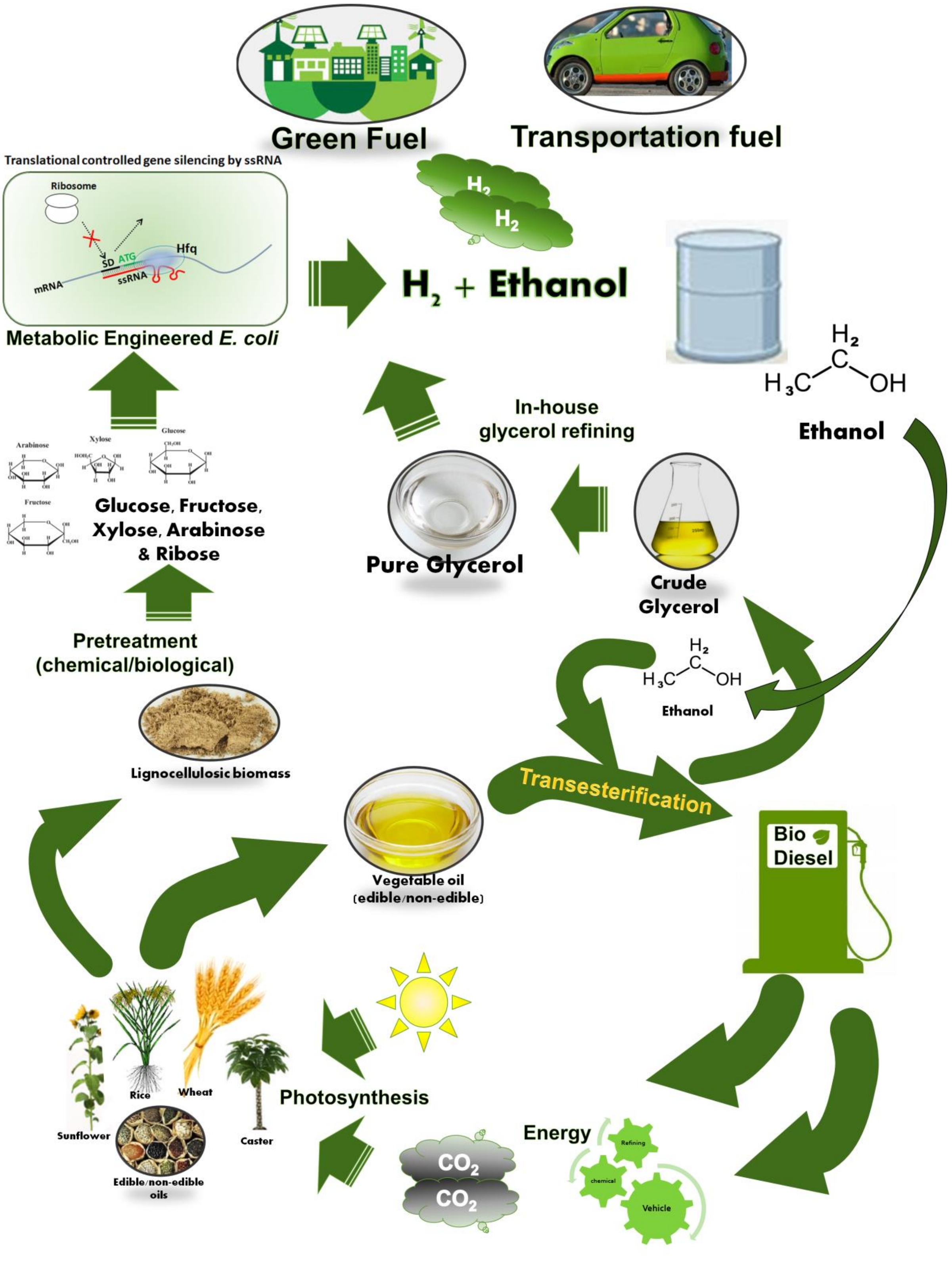
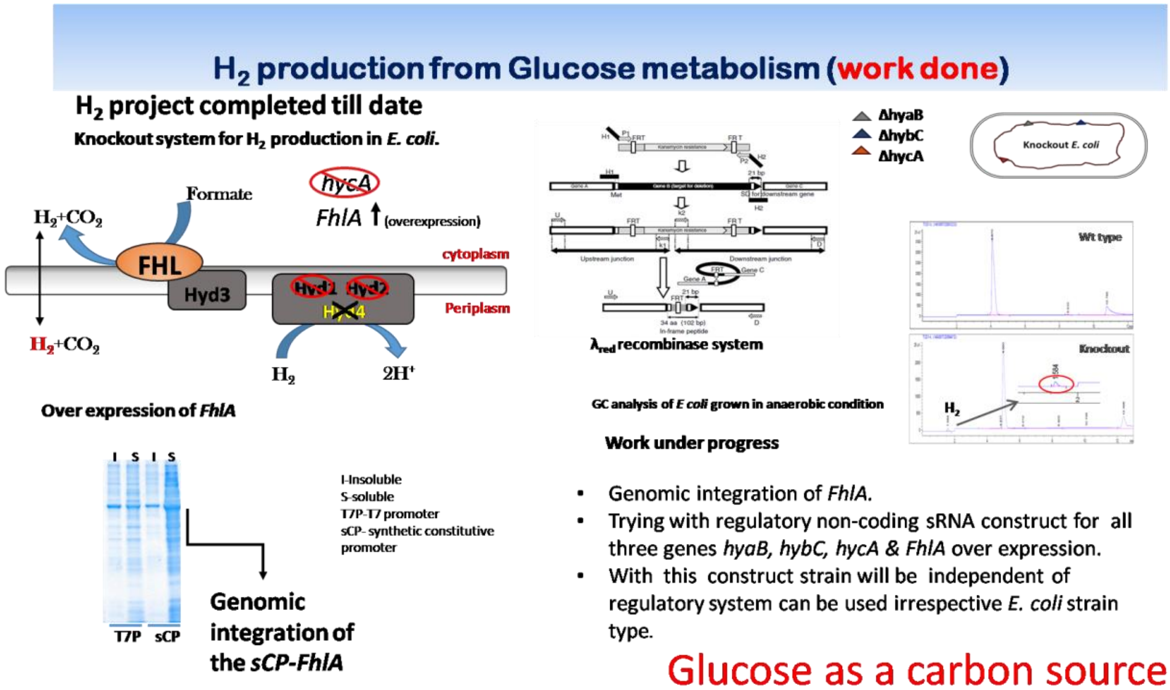


Figure 2. Enhanced H_2 production via Physical knockout of *hyd2, hyd 2, hyd4* and *hycA* in *E. coli* (W3110) .



1) Velarization waste biomass to biofuels and biochemicals

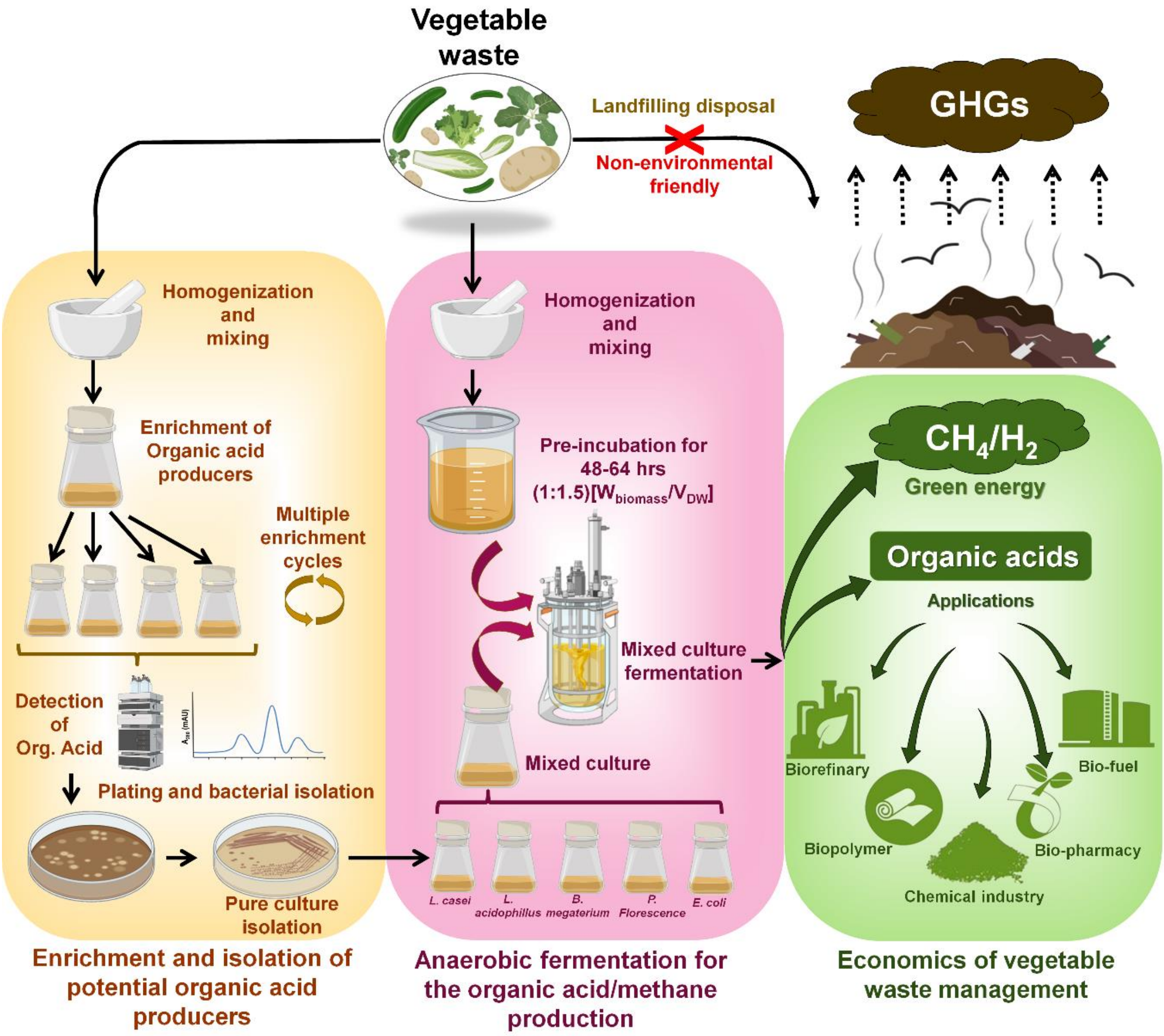
In recent years the keen interest of industries shifted from depending on traditional hydrocarbon-based carbon building blocks towards green synthesis via microbial fermentation. Organic acids come under the carboxylate platform and act as biobased chemical building blocks that can help in the green synthesis of many valuable chemicals. The library of organic acids such as acetic acid, oxalic acid, lactic acid, propionic acid, butyric acid, fumaric acid, malic acid, succinic acid, itaconic acid, citric acid, glucaric acid, and gluconic acid, can be derived from microbial fermentation and acts as chemical raw material These organic acids have applications as feedstocks in the synthesis of chemicals whose utilities start from food additives and act as raw material to produce polymers, synthetic intermediates, pharmaceutical agents, metal chelator, nylon, polyester production, therapeutics, fragrance/aroma ingredients, and in the synthesis of biodegradable polymers, complexing agents and also used as green solvents.

The production of various organic acids from vegetable waste *via* a facile and cost-effective method utilizing characterized synthetic microbial consortia is designed in our study. Five bacterial species with the ability to produce organic acids from vegetable waste biomass were isolated and identified as *Lactobacillus casei*, *Lactobacillus acidophilus*, *Bacillus megaterium*, *Pseudomonas florescence* and *Escherichia coli*. Using these cultures, mixed acid fermentation was developed and was demonstrated to produce various organic acids. The total organic acids accumulated using optimized fermentation conditions was found to be 72.44±3.43 g L^{-1}. The acetic acid was produced as major acid accumulated up to 25.27±1.26 g L^{-1}, followed by lactic acid 19.11±1.73 g L^{-1}. Efforts were also put forth to check the ability to produce methane by the anaerobic digestion process. Up to 14.97mL g^{-1} biomass methane was produced during the anaerobic digestion process. The technology developed in this study is a carbon-neutral process for managing vegetable food waste with economic benefit. The developed technology will have great economic potential and add value to vegetable food waste management. Concept of waste management demonstrated in the above study is illustrated in figure 1.

Publications:

8) Mishra M, Chauhan C, Balasubramianian V, Sudheer P *, Facile bioconversion of vegetable food waste into valuable organic acids and green fuels using synthetic microbial consortium, Korean Journal Chemical Engineering (2021), 38(4), 833-842 (IF: 3.30).

Fig. 1: Process of biofuel and biochemical production via waste biomass (vegetable waste) management.



Annexure 1: publications first pages

1)

Tanushree Baldeo Madavi[1,‡]
Sushma Chauhan[1,‡]
Meenakshi Jha[1]
Kwon-Young Choi[2]
Sudheer D. V. N. Pamidimarri[1,*]

Biohydrogen Machinery: Recent Insights, Genetic Fabrication, and Future Prospects

The increase in global carbon footprints forced mankind to look for alternative carbon-free fuels. Biohydrogen is an ideal fuel, free of carbon footprint, which has the potential to replace fossil fuels. Its high energy content per gram has a great commercial value. Bacteria, cyanobacteria, and algae are developed with various cellular machineries for hydrogen production. Detailed information on these hydrogen-producing cellular machineries, their mechanism of catalysis, and modern genetic engineering and fabrication studies for the enhancement of hydrogen production are reviewed and discussed.

Keywords: Biohydrogen, Biophotolysis, Dark fermentation, Genetic engineering, Hydrogen production

Received: October 31, 2020; *revised:* May 04, 2021; *accepted:* June 24, 2021

DOI: 10.1002/ceat.202000527

1 Introduction

Over the years, the usage of non-renewable hydrocarbon-based fuels and their arbitrary usage policies by various nations led to the rise of the global carbon footprint, and its consequences are now being perceived in the form of global climate change. Moreover, globally the demand for energy is increasing exponentially. The depleting hydrocarbon resources are pushing mankind to look for carbon-free energy resources [1]. Besides hydroelectricity, wind, solar energy, hydrogen (H_2) fuel is non-carbonaceous energy with zero emission. H_2 holds a high-energy content per weight (120.9 $kJ\,g^{-1}$), which is nearly three-fold higher than that of conventional gasoline (48.3 $kJ\,g^{-1}$) and natural gas (44 $kJ\,g^{-1}$). On combustion, H_2 produces only water and the present infrastructure is amendable for future H_2 applications.

The characteristic features of H_2 are suitable for various applications like metal refinement, space exploration, metallurgy, petroleum refinement, and synthesis of many commodity chemicals and, most importantly, as transportation fuel [2]. H_2 seems to be a prospective alternative fuel of choice, which can replace hydrocarbon-based fuels. Though H_2 by nature is a zero-emission fuel, unless the process of H_2 production is zero/neutral emission in nature, it cannot be considered as green fuel or carbon-free energy.

Presently, commercial production of H_2 occurs via physicochemical or electrochemical methods and both are reported not to be carbon-neutral [3]. Unless the production method is carbon-neutral, the benefit of H_2 utilization cannot be extracted by replacing hydrocarbon-based fossil fuels [3]. Hence, in this context, the microbial cell apparatus which can generate H_2 with neutral emission is gaining significance. Moreover, the process of biological H_2 production is completely renewable. Thus, microbial H_2 synthesis is expanding the interest in the scientific community to understand and gain knowledge regarding the cellular apparatus and mechanism of H_2 production.

Through evolution, many biological cells evolved with various cellular apparatus with the ability to produce H_2 which could be utilized by cells for various metabolic processes or as a by-product during the synthesis of essential cellular biomolecules. Among these, various fermentative bacteria, photosynthetic cyanobacteria, and some algae are recognized as efficient cell factories that could generate enough quantities of H_2 fuel with minimal bioenergy input. From a physiological point of view, hydrogenases (H_2ases)/nitrogenases (N_2ases) which are the major enzyme complexes producing H_2 in the cells, act as redox safety valves neutralizing excess of reducing power and regeneration of coenzymes. Besides, these apparatus function as redox buffer units protecting cells from oxidative bleach.

The H_2 producing apparatus is crucial rather than subsidiary and must be maintained in balance for the good health of the cell. Hence, for H_2 production enhancement or optimization, and for fabrication, a comprehensive knowledge of these cellular apparatus is needed. To date, many reviews are published considering microbial hydrogen production [4–10]; however, comprehensive information on cellular apparatus and their conclusive mechanism is scarce in the literature. In this review, major attention is given to discuss various cellular machineries

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‡*These authors contributed equally to this work.*

3)

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REVIEW ARTICLE

Bacillus subtilis as a robust host for biochemical production utilizing biomass

Seo A. Park[a*], Shashi Kant Bhatia[b,c*], Hyun A. Park[a], Seo Yeong Kim[a], Pamidimarri D. V. N. Sudheer[d], Yung-Hun Yang[b,c] and Kwon-Young Choi[a,e]

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ABSTRACT

Bacillus subtilis is regarded as a suitable host for biochemical production owing to its excellent growth and bioresource utilization characteristics. In addition, the distinct endogenous metabolic pathways and the suitability of the heterologous pathways have made *B. subtilis* a robust and promising host for producing biochemicals, such as: bioalcohols; bioorganic acids (lactic acids, α-ketoglutaric acid, and γ-aminobutyric acid); biopolymers (poly(γ-glutamic acid, polyhydroxyalkanoates (PHA), and polysaccharides and monosaccharides (N-acetylglucosamine, xylooligosaccharides, and hyaluronic acid)); and bioflocculants. Also for producing oligopeptides and functional peptides, owing to its efficient protein secretion system. Several metabolic and genetic engineering techniques, such as target gene overexpression and inactivation of bypass pathways, have led to the improvement in production titers and product selectivity. In this review article, recent progress in the utilization of robust *B. subtilis*-based host systems for biomass conversion and biochemical production has been highlighted, and the prospects of such host systems are suggested.

ARTICLE HISTORY
Received 17 September 2020
Revised 6 November 2020
Accepted 26 November 2020

KEYWORDS
Bacillus subtilis; bioorganic acids; biopolymer; biosugar; surfactant; surfactin; functional peptides

Introduction

The development of sustainable chemical and energy production in an ecofriendly manner has become important as an alternative to fossil fuels and to mitigate global climate change. However, the energy production paradigm relies on petrochemical-based chemical reactions and conversion processes. However, owing to climate change and strict regulations on the management of hazardous substances, research on biotransformation technologies that can replace chemical reactions is ongoing. Of course, the two processes themselves have different intended products and applications, and there is a high possibility that synergies can be created. In particular, biotransformation reactions based on biological processes play a unique role that cannot be replaced by chemical processes [1].

The use of microorganisms in fermentation, bioproduction, and biotransformation processes has a long history and has recently developed radically because of technological advances in the screening, cultivation, and genetic engineering of various strains of microorganisms [1]. In particular, in the process of securing energy through soil-based plant cultivation, many useful microorganisms derived from soil have been found and identified [2,3].

Bacillus subtilis, a representative soil microorganism, is a Gram-positive bacterium well known for forming spores [4]. It is a generally recognized as a safe (GRAS) species that has been intensively studied and utilized for the production of a variety of biochemicals [5]. It can metabolize a vast array of substrates ranging from glucose to budgetary carbon feedstocks such as food, pulp, and agricultural waste [5,6]. The absence of an outer membrane and well-characterized secretion pathways in *B. subtilis* facilitates the efficient relocation of proteins into the extracellular space [7]. Therefore, *B. subtilis* has been one of the most powerful cell factories for the extracellular production of enzymes and peptides. In addition to efficient protein production, these

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*Those who contributed equally.

4)

3 Bio-Hydrogen: Technology Developments in Microbial Fuel Cells and Their Future Prospects

Pamidimarri D. V. N. Sudheer, Sushma Chauhan, and Balasubramanian Velramar

Abstract

The energy is the part of the human evolution; the innovation in the transportation and industrial evolution happened in this century made mankind to depend on fossil fuels invariably. The depletion of fossil fuel resources and global carbon footprint accumulation are worrying the global countries for the future environmental safety. The clear policies were amended to come out of releasing the global carbon footprint by many countries; even developing countries are making it compulsory for controlling or reducing greenhouse gases releasing in to environment. In this context hydrogen fuel is getting promising significance since it has high energy content per unit mass, and up on combustion it will not release any carbon footprint and considered to be complete green energy. Though there are many chemical and physicochemical methods available for the production of H_2, biological H_2 production will be superior since this method do not use harsh chemical process and do not need extreme conditions for the production. Hence, many research studies are put forward for the production of biological hydrogen production. In this book chapter we will have comprehensive discussion on these technologies developed for the hydrogen production till date. This chapter also included the next generation technologies which are in acceleration in engineering the strains for the enhancing the productivity and various other parameters like utilization of waste biomass and waste industrial affluent etc. This chapter also included with the list of aspects to be looked for the future development of H_2 as the next generation fuel energy.

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N. Kumar (ed.), *Biotechnology for Biofuels: A Sustainable Green Energy Solution*,
https://doi.org/10.1007/978-981-15-3761-5_3

5)

Biofuels: Sources, Modern Technology Developments and Views on Bioenergy Management

8

Sushma Chauhan, Balasubramanian Velramar, Rakesh Kumar Soni, Mohit Mishra, and Pamidimarri D. V. N. Sudheer

Abstract

Increasing energy demands and the rising global carbon footprint are forcing mankind to look for alternative green fuels. Fuels derived from biological sources are considered to be green fuels since they do not release toxic pollutants upon combustion. The global accumulation of the carbon footprint and accelerated demands on energy are pushing us to look for alternative green fuels based on renewable resources. Hence, identification of potential sources of green fuels produced by biological means and utilization of these resources for commercialization provide the context of the priorities for future energy needs. The two major concepts considered for next-generation green fuels are (i) fuels that do not increase the carbon footprint (e.g. hydrogen fuel) and (ii) utilization of photosynthetic processes to fix CO_2 and produce biofuels. Keeping these two priorities in mind, this chapter provides a detailed discussion of various biofuels available for mankind, which can replace traditional hydrocarbon-based fossil fuels. These biofuels could help in reducing the global carbon footprint. The chapter gives information about the various biological sources for production of biodiesel and microbial sources for production of liquid fuels. This chapter also discusses the concept of microbial fuel cells, the importance of biohydrogen, aspects of molecular engineering of organisms to enhance productivity, fabrication of microbial systems for production of biofuels and the prospects for biofuel production by utilizing modern biotechnology tools.

Keywords

Biofuels · Microbial fermentation · Biodiesel · Biohydrogen and microbial fuel cells

S. Chauhan · B. Velramar · R. K. Soni · M. Mishra · P. D. V. N. Sudheer (✉)
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https://doi.org/10.1007/978-981-15-3761-5_8

8)

Korean J. Chem. Eng., 38(4), 833-842 (2021)
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pISSN: 0256-1115
eISSN: 1975-7220

Facile bioconversion of vegetable food waste into valuable organic acids and green fuels using synthetic microbial consortium

Mohit Mishra, Sushma Chauhan, Balasubramanian Velramar, Rakesh Kumar Soni, and Sudheer Deva Venkata Narayana Pamidimarri†

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(*Received 24 August 2020 • Revised 6 December 2020 • Accepted 23 December 2020*)

Abstract–The production of various organic acids from vegetable waste *via* a facile and cost-effective method utilizing characterized synthetic microbial consortia is described in this study. Five bacterial species with the ability to produce organic acids from vegetable waste biomass were isolated and identified as *Lactobacillus casei*, *Lactobacillus acidophilus*, *Bacillus megaterium*, *Pseudomonas florescence* and *Escherichia coli*. Using these cultures, mixed acid fermentation was developed and was efficient in producing various organic acids. The total organic acids accumulated using optimized fermentation conditions was found to be 72.44±3.43 g L^{-1}. The acetic acid was produced as major acid accumulated up to 25.27±1.26 g L^{-1}, followed by lactic acid 19.11±1.73 g L^{-1}. Efforts were also put forth to check the ability to produce methane by the anaerobic digestion process. Up to 14.97 mL g^{-1} biomass methane was produced during the anaerobic digestion process. The technology developed in this study is a carbon-neutral process for managing vegetable food waste with economic benefit. The developed technology will have great economic potential and add value to vegetable food waste management.

Keywords: Carbon Footprint, Landfill Disposal, Organic Acids, Synthetic Microbial Consortia, Vegetable Waste Biomass

INTRODUCTION

In recent years the keen interest of industries shifted from depending on traditional hydrocarbon-based carbon building blocks towards green synthesis via microbial fermentation. Organic acids come under the carboxylate platform and act as biobased chemical building blocks that can help in the green synthesis of many valuable chemicals [1,2]. The library of organic acids such as acetic acid, oxalic acid, lactic acid, propionic acid, butyric acid, fumaric acid, malic acid, succinic acid, itaconic acid, citric acid, glucaric acid, and gluconic acid, can be derived from microbial fermentation and acts as chemical raw material. These acids range from C_2 to C_6 and are presently produced at the commercial level by microbial fermentation, occupying up to 5-10% of the total industrial production scale [1]. In recent years, higher chain diacids also have been reported *via* whole-cell biocatalysis utilizing vegetable oils with the help of recombinant strains [2,3]. These organic acids have applications as feedstocks in the synthesis of chemicals whose utilities start from food additives and act as raw material to produce polymers, synthetic intermediates, pharmaceutical agents, metal chelator, nylon, polyester production, therapeutics, fragrance/aroma ingredients, and in the synthesis of biodegradable polymers, complexing agents and also used as green solvents [1,4]. However, this adaptation is not in the desired acceleration to attain success at the commercial level. This hindrance is due to the cost incurred for the production of organic acids via microbial fermentation since biorefinery relies on costly culture media and the defined nutrients. Hence, researchers are looking to utilize low cost or waste biomass to produce organic acids; thus the production cost comes down and can attain commercial feasibility.

Urbanization is accelerating in larger cities, leading to the increased discharge of vegetable/food waste from the domestic and food industries. The vegetable/food waste discharge is presently a major urban issue because the protocols used in waste management elicit carbon emissions. Most of the nation's local governance primarily manages waste discharge *via* the landfilling method. Landfilling comes under the non-green disposal method as the wet solid waste, which includes the vegetables, food, kitchen waste generated by the domestic/commercial/food market/food processing industry, is rich in carbon and nitrogen sources along with the macro and micronutrients. Hence, is very much suitable for microbial growth [5,6]. In conventional landfilling disposal, the wet food waste upon the disproportionate microbial activity will result in methane and other greenhouse gases released into the environment. Hence, causing global carbon footprint accumulation [7]. According to the National Food and Agriculture Organization, up to 8% of global carbon footprint emission is due to improper vegetable/food waste management. Moreover, it is also responsible for local pollution, groundwater perturbance, and the release of toxic greenhouse gases through anonymous decomposing activities by the various microbiome. Hence, many countries with a high population density, e.g., the Republic of Korea, have banned landfilling disposal methods for vegetative food waste and/or domestic kitchen waste [8]. Thus, environmental research has shifted towards utilizing this waste to generate biochemical building blocks like organic acids. Organic acids can act as raw materials for the green synthe-

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AMITY UNIVERSITY, CHHATTISGARH

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RAIN WATER HARVESTING AND WATER MANAGEMENT

Contents

1.0 Preamble

Fresh water is turning out to be an increasingly valuable and scarce resource as its demand-supply gap keeps rising at an incredible pace. The availability of both ground and surface water is becoming increasingly difficult owing to the heavy usage for agricultural, industrial and domestic purposes. The recent years have seen a fast-changing regulatory landscape with increasingly stricter regulations on the industrial water consumption. This is an increasing risk to the organisations requiring water as their major input. As a frontrunner in the education industry, Amity University Chhattisgarh (AUC) owes the responsibility to tackle this issue of water availability by reducing its consumption, thus setting new industry benchmarks on one hand and exploring alternate methods to ensure long term water security. Water Policy had been formulated to give direction to such efforts.

Rain water harvesting (RWH) is a way of collecting and storing rain water either for reuse or for ground water recharge. It possesses tremendous potential to reduce fresh water consumption and act as a reliable secondary source of water. AUC shall prioritise surface water storage and reuse over ground water recharge, because

a) Surface storage and reuse is more useful. Ground water recharge is a slow process and majority of water recharged done is not available for intended use subsequently;
b) It will lead to reduction of burden on other water bodies such as rivers, lakes and ground water sources; indirectly contributing to water table improvement;

To strengthen its water conservation initiatives, AUC has developed Rain Water Harvesting Policy which would act as the major guiding document for rain water harvesting. Considering the importance of water as a shared resource, this policy can be further used as a reference for the various water conservation initiatives taken up by AUC and its various projects.

2.0 Objective

To promote the installation and periodic upkeep of Rain Water Harvesting system in locations of and near to NTPC establishments.

3.0 Applicability & Scope

This policy is applicable to

3.1 All the establishments of AUC thus including projects, stations, administrative offices, hostels, residential quarters and guest houses;

3.2 Locations with and without existing rain water harvesting system;

4.0 Principles

This Policy is guided by following principles:

4.1 Rain water harvesting (RWH) system, though functional only for a brief duration in a year, is useful as a secondary source of water;

4.2 Adoption of right combination of superior state-of-the-art technologies and global best practices shall increase the quantity and quality of harvested rainwater;

4.3 Provision of accountability for all locations and mechanism to respond to any aberration from the policy objectives shall yield superior results;

4.4 Promotion of RWH through inclusiveness, capacity building and regular knowledge sharing with concerned stakeholders shall result in capturing of increased quantity of rainfall that would have gone unused otherwise;

5.0 Elements of RWH

A RWH system typically consists of following three elements:

a) Collection system or catchment area
b) Conveyance system and
c) Storage/ recharge system with the provision of treatment system, if required

We have to design our system to capture and store all possible rainfall by covering maximum possible catchment areas with optimum storage capacity through extensive networks of conveyance or storm drains

5.1 **Catchment Areas**

5.1.1 It is the first point of contact of rainfall where surface water from rain gets collected, drains towards the common outlet and joins storage tanks, recharge pits, reservoirs etc.

5.1.2 Potential catchment areas for AUC units have been tabulated below

S. No	Unit	Catchment Area
1	Stations/ Projects	1. Roof top of all buildings including academic building, Hostels, canteen, parking shed etc. 2. Lawns/ Garden Area / Vacant Land 3. All the proposed sites. 4. Security office, Chiller plant, Sub-station etc., 5. Open areas 6. Roads/ Pavement

5.1.3 Depending on the pollution levels of different catchment areas and quality of collected rainwater, its subsequent use shall vary as illustrated as below:

5.1.3.1 Medium to good quality

Catchment A: Rooftop area

The quality of water is quite good and can be used to store locally to meet the washing and flushing requirements of concerned building. Buildings with existing dual plumbing system can integrate this easily.
Excess water can be diverted to ground water recharge with overflow connected to storm water drains to feed into raw water reservoir in plants and/ or to natural drains elsewhere.

Catchment B: Hard paved area (Roads)

The quality of water collected from this catchment may be a little inferior to that of catchment A, but better than catchment C. This can be fed into raw water reservoir directly.

Catchment C: Landscape/ vacant land area

This category includes storm water from lawns, gardens and open areas. Water collected from these areas contain soil, debris etc. and may need primary level filtration before releasing it into the reservoir

5.1.3.2 Poor quality

Catchment D: Areas near to construction sites and sand/dust handling facilities Surface runoff from the such areas/facilities may be contaminated with dust/ash particles. Similarly, areas near to Ash handling facilities will contaminate the storm runoff with ash. The storm water collected from these areas shall be stored and used locally instead of connecting it to storm water drains.

Catchment E: Areas with possibility of oil contaminations Rain water collected from areas near to transformers, waste oil storage, drainage near machines etc. should not be connected to storm water drains. They may be connected to ETP drains instead of storm water drains or first treated before connecting it to storm water drains. Rain water collected from rooftop, paved or ground run-off near health centres etc., dealing with Bio-medical waste, shall be designed with utmost safety and hygiene.

5.2 Conveyance through separate storm water drain:

All AUC sites/buildings/ projects have created a separate drain system to capture the storm water mainly from the rainfall in the catchment A, B and C. It has been ensured that the sewage water or industrial waste water/waste from labs does not seep into storm water drain resulting into contamination of storm water. Intermediate retention pits are created depending on the topography of the area to hold the storm water and then further pump it to next elevated area. Finally, all the storm water has been diverted to the final holding pond either through gravity or pumping. This water is further treated with some basic filtering mechanism to be finally released into raw water reservoir. Widened and deepened channel with provision of pumping and other necessary arrangements will be part of holding pond arrangements. Overflow from holding pond will be diverted to natural drains connecting the nearby river bodies such as lakes, rivers etc.

5.3 Surface storage

As mentioned above, the collected rain water shall be finally released into raw water reservoir for surface storage, the same shall be facilitated through creation of holding ponds, pump houses and network of pipes according to the need of specific locations.

5.3.1 Site Locations

As rainfall pattern varies from location to location owing to the varied topography, different strategies for water storage have been adopted for different areas. The different establishments have been further classified into the following zones depending on the average annual rainfall data.

Zone A: High rainfall area with rainfall more than 1000 mm Rainfall in this area can be a reliable source of water throughout the year. Hence, the focus should be on storing water in the existing raw water reservoir with modifications or through creation of additional storage. The stored water will be used in domestic processes with minimum intake from outside sources.

Zone B: Medium rainfall area with rainfall between 500 mm to 1000 mm Such areas will capture less rainfall compared to zone A areas and hence existing reservoir can be modified to the extent which will be able to capture the average rainfall. Additional storage may be created in cases where enough water can be stored for a substantial period of time with good amount of use.

Zone C: Low rainfall area with rainfall less than 500 mm These areas will capture less rainfall compared to zone A and zone B and existing reservoir would be able to store the rain water, if any. In all of the above cases, rainfall captured in residential colonies may be diverted to plant for storage and reuse. Also, **additional storage may be preferably created in lowest elevation area subjected to the availability of space**. There shall be a provision of channelling out the excess water beyond storing capacity to outside (natural catchments of nearby river, lakes etc.) to avoid flooding.

5.3.2 AUC Building Locations:

All Locations of AUC buildings have installed rain water harvesting system in the available space through either overhead or underground storage for meeting their daily water requirement especially in rainy season. Also, the catchment area available would be mainly rooftop area and as this water is quite pure, it is stored and filtered for domestic usage. The sizing of storage structure shall be done on the basis of water demand, average annual rainfall, number of rainy days etc.

5.4 Ground Water Recharge

Ground water recharge incorporates many factors such as topography, hydro-geology, water table, quality of water etc. There is no benefit of creating artificial ground water recharge system if water table is already high or soil permeability is very less in the concerned area. Central Ground Water Board/State Ground Water Board may be consulted for proper scheme wherever it is mandatory under conditions of Environmental Clearance/Consents.
AUC has at present 05 Artificial Ground Recharge pits in working condition, and 20 more are planned near the proposed sites.

5.4.1 Ground Water Recharge Locations

There is some possibility of contamination from surface and air pollutants, typical from a coal fired power station (AUC is near coal-based power plant), to surface water recharge system. Also, water table may be estimated to be good in high rain fall areas (zone A and B areas). Hence, ground water recharge shall be preferred over surface storage and reuse in AUC residential premises.

5.4.2 Office Locations

AUC owned buildings may consider artificial ground water recharge only or in combination with surface storage and reuse, whichever is suitable to the concerned locations.

6.0 Quality Monitoring Systems

Proper quality monitoring system has to be created to regularly check the quality of collected storm water into the holding pond before it is finally released into raw water reservoir. The quality checks shall be done by Chemistry department and by competent authority/ professionals.

7.0 Measurement

The rain water harvesting potential of an area can be estimated through the following formula:

Water captured (L) = Catchment area (m2) X annual average rainfall (mm) X run-off coefficient
Surface run-off coefficient is a dimensionless parameter and related to the amount of runoff to the amount of precipitation received.

8.0 Maintenance of RWH system

Periodic maintenance of rain water harvesting system is mandatory to ensure its functionality resulting into availability of good collected rain water both in terms of quality and quantity.

8.1 Catchment

Before the onset of rainy season all the catchment areas A, B & C including the roof of all buildings, roads, vacant lands need to be cleaned thoroughly to remove debris, twigs, plant/tree residues, plastic etc.

8.2 Conveyance system of pipes and drains

All pipes/ joints need to checked for any leakages. Storm water drains to be cleaned and freed of silt, sludge, debris etc. to avoid any possibility of obstruction in flow. All drains need to covered with the provision of storm water entrance, to prevent the contamination and any safety hazard.

8.3 Pumps and electrical systems

Timely maintenance of various pumps, auto-on/off switches, earthing system etc. to be checked and ensured.

8.4 Storage and filtering

All the storage areas need to be cleaned for sludge etc. In case of presence of a filter unit, it has to be regularly cleaned and washed or replaced.

8.5 Recharge systems

If there is any recharge system in residential areas, RHQs, offices, the same has to maintained by removing the silt deposited at the bottom of structure.

9.0 Budget

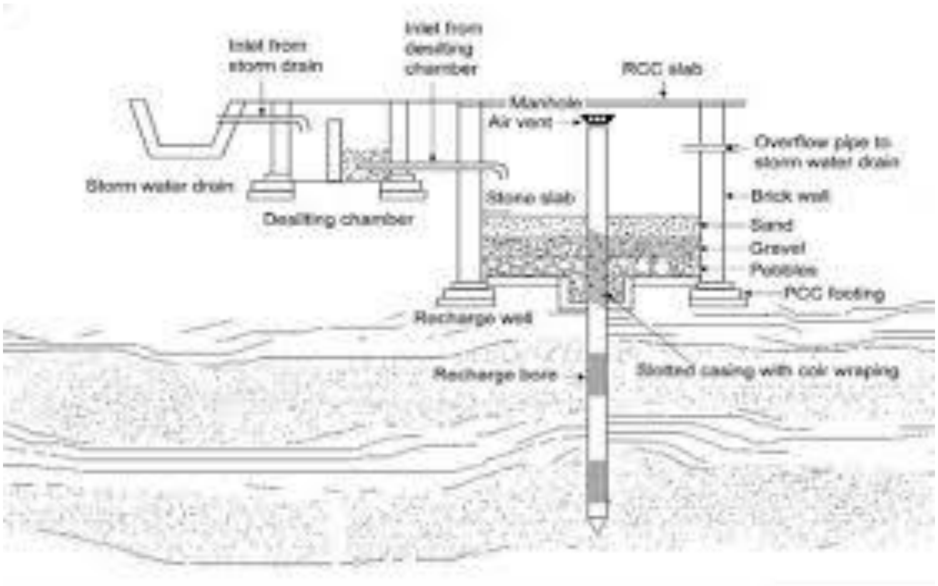
Suitable budget may be allocated for installation and renovation of RWH system at AUC.

10.0 Review

10.1 The review of effectiveness of a rainwater harvesting systems in all locations shall be done during water audit annually.

10.2 This policy shall be reviewed at opportune time, but not later than once in three years.

Fiq. 1



Artificial recharge is the process of spreading or impounding water on the land to increase the infiltration through the soil and percolation to the aquifer or of injecting water by wells directly into the aquifer. Surface infiltration systems can be used to recharge unconfined aquifers only. Confined aquifers can be recharged with wells that penetrate the aquifer. Well recharge is also used for unconfined aquifers if suitable land for infiltration systems is not available.

Fiq. 2 Artificial Ground Water Recharging Pit under construction.

Here at Amity University Chhattisgarh 05 such rain harvesting pits are constructed though we have plan of constructing total 25 such Artificial Recharge Systems.

AMITY UNIVERSITY, CHHATTISGARH

ESTABLISHED UNDER THE CHHATTISGARH PRIVATE UNIVERSITIES (ESTABLISHMENT AND OPERATION) (AMENDMENT) ACT, 2014 (CHHATTISGARH ACT NO. 13 OF 2014)

ACTION PLAN
TO REDUCE PLASTIC IN CAMPUS

Going plastic-Free

Now here's a major challenge – a "Plastic-Free Campus". The ubiquitous presence of plastic in our daily lives might make this seem like an impossible task. Furthermore, plastics have played a huge role in technological innovation to do a lot of good for a lot of people. But, DO NOT BE DISCOURAGED! Your target is single-use, disposable plastic… and it's totally doable! Becoming plastic-free is a process that won't happen overnight, so keep in mind these key tips:

1. **Start small**, perhaps with a **Pilot Project**, and build on your successes

2. **Educate yourself** and others on the harms of plastics

3. **Rally support** from all types of stakeholders on the campus

4. **Make a plan** of action! While the implementation will be difficult, we and our peers have the power to reduce plastic pollution!

What does it mean to go plastic-free?

Plastic has become an almost-unavoidable part of modern everyday life. It's affordable, easy to mass-produce, and ideal for many innovative technologies. Pledging to transition away from disposable plastics is pledging to end the consumption of single-use items destined for a landfill. It can start with an elevated education about the consequences of plastic production and consumption, and a removal of basic products like plastic bottles and bags, plastic film, and other unnecessary product packaging. While plastic alternatives can be costly, the long-term health and environmental benefits of going plastic-free far outweigh the initial monetary costs.

Navigating the Project

All campuses are different: what works at one school may require more attention, more push, or may not work at all, for ours. From the passing of bans that have essentially fallen into students' laps, to initiatives that resulted in unintended consumption of other plastic items. You will find that our University has a specific pace to be followed. Our student group working towards zero waste must explore the kind of attention our institution needs. Ask yourself these questions regarding single-use disposable plastics:

- What do you perceive to be the most concerning issues regarding plastic use on our campus?

- What single-use disposable plastic items are most prevalent on our campus?

- Which "problem" plastics should be a priority target?

- What form of action should we take: a ban, a reduced-price incentive for reusables, or simply more education entailing the consequences of plastic use?

Seven Reasons to go Plastic-Free

1. Single-use disposable plastics have a **massive carbon footprint**. Whether made from petroleum or plants, plastic manufacturing is not efficient due to the scale of production.
2. Both the production and disposal of single-use plastics often emit massive amounts of dioxins, a highly toxic by-product linked to increased cancer rates and other **human health effects**.

3. **Plastic lasts forever**: Plastic can never be broken down by natural processes; every particle of plastic that has ever been created still exists in a form toxic to all terrestrial and marine life.
4. Plastics can be **challenging to dispose of**. Not all localities have the infrastructure to recycle single-use plastics; thus, many recyclable plastics take up valuable landfill space. When not able to be recycled or landfilled, they are often sent to incinerators, emitting environmental toxins into the atmosphere.
5. Plastic **poisons our food chain**: It is increasingly found in the ocean and guts of marine life, extending to affect the health of human populations who rely on fish and other marine life for food sources.
6. Going plastic-free can **save you money**! Relying on reusable items enables you to avoid constant purchasing of disposable items.
7. Single-use plastic items perpetuate a **wasteful, throw-away culture**. Our society is far too valuable to be thrown away! Brought to you by PLAN and the Plastic Pollution Coalition.

Now that we've got the facts about issues surrounding plastic pollution, we want to help you take action! Among all of the following best practices to becoming plastic-free, we outline:

- **How to navigate our campus and local community infrastructure**
- **Existing initiatives, campaigns, and legislation targeting single-use plastics, and where to find information about plastic-free initiatives near us**
- **How to conduct a Plastic Audit, and use that information to make a plan of action**
- **Alternatives to specific single-use plastic items, and resources for further support!**

Preparing for Pushback

As mentioned, we may receive pushback about going plastic-free. Be prepared for critics to challenge us with these myths about plastic bag bans and going plastic-free:

Reusable bags spread bacteria: Some studies out there try to make the case that reusable bags encourage the spread of infectious disease through harbouring bacteria like E. Coli. The reality is that bacteria is found on EVERYTHING, including single-use plastic bags. If your reusable bag is dirty, give it a wash or wipe it down. It's also good practice to use separate bags for meat and produce.

Reusable bags are toxic: Any synthetically made product has the potential to contain unsafe amounts of heavy metals or other toxic compounds. Eco-friendly intentioned products are no exception to this. Likewise, reusable bags are no more likely to be toxic than their disposable counterparts. Navigating this is part of being an informed consumer!

Banning plastic bags means people will just use disposable paper bags instead: That is certainly a logical assumption, but paper bags can be the lesser of two evils. They are more easily recyclable AND have the ability to be composted. Oftentimes, bag bans will put charge a small fee onto other disposable bags, so that consumers are still encouraged to bring reusables.

Charging for single-use bags is just a scam for stores to make money: Fees applied to single-use bags are used to fund an establishment's procurement of more durable (thus, more expensive) bags to comply with the law. The consumer was never getting single-use bags for free in the first place; the cost of procuring them is often tacked onto the prices of products that the establishment sells.

Know Your Stuff:

Campus & Community Infrastructure

Start big and learn the status of the area surrounding our University in regard to any kind of plastic ban or legislation. This knowledge is a powerful tool in moving our campus to take steps. Once we know, we can act. The second half of this action plan covers who to talk to make change.

Local Laws and Regulations

As the general public becomes more aware of the dangers of single-use disposable plastics, new legislation is calling for sustainable alternatives. While not always obligated to follow suit, universities and colleges can adopt local regulations or ordinances if the campus population expresses support. These community laws can provide a baseline for new student campaigns, or a final push for on-campus initiatives.

So where do we find all this information?

There are a variety of resources to consult, including web resources from leaders in the plastic-free movement, to talking with city council representatives. Check out the following web resources to find out if bag bans and other plastic free initiatives exist in our area:

- Chico Bag's "Track the Movement" interactive map
- The National Conference of State Legislation site detailing passed and proposed plastic bans by the State
- The Plastic Bag Ban Report for bans nationally and worldwide
- The Surfrider Foundation
- Social media hashtags: #bagban, #banthebag, #plasticbags, #banthebead, #plasticpollutes, #bringyourown

Existing Campaigns:

AUC - Administration has banned polystyrene (Styrofoam™) in campus food establishments only to find that dining services had already begun taking steps to phase-out the material on their own accord. Students latched onto this discourse and kept close communication with dining services to consult them on what a polystyrene phase-out would look like. This group (Administration + Student groups from various streams) established a petition committee to draft effective policy language, and delegate the proposal out to individual campus food vendors. It was also helpful to have a community member who worked for World Centric, a company that manufactures compostable to-go ware, as a part of the petition committee to be able to attest to the affordability of compostable alternatives. Student organizers recognized that, had they drafted the proposal alone without input from a variety of campus representatives, they would have faced much more pushback. Ultimately, the combined force of Administration, students and dining hall operations made passing of the ban, and its subsequent implementation, more effective.

Existing Municipal Ordinances & Bans

City ordinance or District Authorities, prohibits the use of polystyrene to-go containers by all food service operations in Raipur. This is in an effort to reduce plastic debris and avoid the potential health impacts of single-use plastic products. The terms are as follows:

- prohibits the use of polystyrene (Styrofoam™) to-go containers by all establishments serving food in Raipur

- requires food vendors and restaurants to use only compostable or recyclable to-go food service ware

With the infrastructure already in place at the local level, the Amity University Chhattisgarh (AUC) implemented a similar policy mandating all private food vendors leasing space on campus to comply with the city ordinance, resulting in the ban of polystyrene on campus.

Existing Campus Policy and Operations

If University has limited recycling capacities for recovering single-use plastic items, there is all the more reason to eliminate these items on campus. However, for schools with recycling infrastructure, full blown bans of plastic items may not financially make sense to campus administration because of recycling rebates and other incentives that campus receives. Talk to Procurement Department as well as the department that handles waste management in our campus to determine if any financial incentives drive campus recycling operations. If this is the case for our campus, there are alternatives out there for our campus to mitigate its plastic footprint:

1) Decreasing campus-wide procurement and consumption of non-recyclable plastics

- polystyrene containers could be replaced with another material.

- Make some campus events or student org programs plastic-free.

2) Encouraging **individual behaviour change** for single-use plastic consumption.

3) Increasing **recycling participation** and reducing recycling contamination on campus.

University (In)Capabilities

AUC has been strategizing to purchase reusable dishware for all eateries on campus. We have even succeeded for one or more locations.

As we've just seen, there are a variety of ways to move towards a plastic-free campus. Existing laws and ordinances may serve to make the switch effortless, or may force us to get creative with our education and outreach efforts. Even if we are able to pursue a solid alternative to single-use plastic products, every alternative will have its own set of complications. For example, compostable products may not be compatible with the composting infrastructure of our campus or surrounding community. Furthermore, these operations might not even exist for us to consider compostable bio-ware as a sustainable plastic alternative.

Collaborating with Departments on Campus

Whether we are trying to pass a ban on campus, change procurement, or establish a reusables campaign, we will need backing from institutions. Remember to include others on campus who are affected by these initiatives. Some examples of important stakeholders to include in our initiatives are:

- dining service workers or food service provider representative: chefs, servers, cafe managers

- campus waste management service staff

- custodial staff

- procurement department staff

- student groups working for campus change: services groups, environmental groups

- professors, faculty, provosts, department chairs

- community members that may be affected remember, having a signature on a petition from a major campus faculty, agreeing to support our initiative or campaign, can go a long way.

TAKING ACTION

Conducting a Plastic Audit

The first step is to conduct a plastic audit. Check out and record the following:

- What plastics are used on campus and where do they come from?
- Which of these items are most frequently used?
- Where are single-use plastics disposed of?
- Who is using single-use disposable plastics on campus?

Plastic audits can be conducted through multiple approaches, and will set the stage for plan of action for a plastic-free campus. No matter which approach we choose, try to be transparent to students and other campus residents about why are we conducting a plastic audit - the sooner we start to educate and outreach the better.

VISUAL ASSESSMENT

Note and track all single-use plastics we see on campus, from trash receptacle contents, to what cafés and campus vendors are distributing to customers. Observe passers by walking to class: What are students carrying? Coffee cups with plastic lids or iced drink cups? Granola bars in plastic wrappers? A sandwich in a baggie or plastic wrap? While taking records of the plastics we observe, keep these questions in mind:

- What kinds of plastics are being thrown away?

- Roughly, what ratio of these are plastics that can be recycled?

- What/How much of that is material supplied by our campus?

- What/How much is being brought onto campus from outside sources?

- Who is associated with these outside sources and how will we communicate with them?

Observe the contents of vending machines on campus. How many in total are they and where are they located? What kinds of plastics appear in them? Which items have potential alternatives?

PROCUREMENT INVENTORY

A procurement inventory provides more verifiable data on campus plastic presence and insight into campus procurement practices. This will require communication with campus dining services, cafes and other eateries, and perhaps the procurement department through which these establishments purchase their products. Ask for a purchasing list and note the specifics of all of the single-use plastic products that are purchased, including:

- How much of the item is purchased
- How much the item costs per unit purchased (include shipping!)
- What company produces each product and/or the supply centre from which it is shipped
- What the product is made of and how it is packaged

This information will be useful for calculating any sort of cost-benefit analysis of plastic product alternatives that can be presented to campus administration. After taking an initial procurement inventory, we can further analyse the products that we have recorded by finding out if product vendors provide alternatives, and what the costs of these alternatives are in comparison to the materials that are currently being purchased.

Formulating A Plan

Once we have conducted a plastic audit identifying the major sources of single-use disposable plastics on your campus, where they come from, and who is using them, follow the steps below to formulate a plan for a plastic-free campus!

STEP 1: FIND YOUR TARGETS

Petroleum-Based Products & Bioplastics

There are many products advertised as plastic alternatives that are petroleum-based and still contain plasticizers, and thus pose similar health and environmental effects to traditional plastics. Try and advocate against these single-use items in our plastic-free initiatives. **Bioplastics are composed of "renewable biomass sources,"** like corn or vegetables oils, that are processed into a compound called polylactic acid (labelled as PLA #7). Their composition makes them less fossil-fuel-intensive in production and less hazardous in disposal. However, there is often a huge amount of energy sources put into growing the crops for the production of bioplastics. While bioplastics are designed to be "biodegradable", this term does not guarantee that an item will fully break down in a compost system. Furthermore, the nature of bioplastics' composition interferes with the operations designated for recycling regular plastics. In other words, we cannot mix bioplastics in with recyclables!

If implementing reusables is not feasible for our campus at the moment and we opt for single-use bio-plastics, we suggest using World Centric products. The majority of plant fibre products from World Centric are composed of wheat straw, a by-product of agricultural production that is often thrown away or burned.

Single-Use Plastics

Freedom from plastic should include all plastic items that would normally be disposed of after one use. This includes (but is not limited to) beverages in plastic bottles, items in plastic wrap or plastic containers, utensils, cups and lids, straws, stirrers, bags, and any disposable polystyrene (Styrofoam) products.

Beyond Bottles and Bags

Single-use plastic bottles and bags are just the first steps to becoming a plastic-free campus. Future purchases of plastic materials should be avoided, when possible, especially when the products are hard-to-recycle or unable to be recycled. For example, plastic shower curtains cannot be recycled and alternatives should be considered when old ones need to be replaced. Another target to be aware of is products containing plastic microbeads.

“Biodegradable” is not the same thing as “compostable”! If an object is biodegradable, that means that is capable of being decomposed by natural processes. This does NOT necessarily mean that the item will break down in a composting system to be used in a finished compost product. There is no time scale requirement for biodegradation - everything will biodegrade eventually. Compostable means that an item or product will break down completely within a given time. Compostable is a term with set requirements in regards to biodegradability, disintegration, and ecotoxicity:

1**) Biodegradability** - 60-90% will break down in 180 days

2**) Disintegration**- 90% of material will break down into pieces 2 mm or less in diameter

3) **Ecotoxicity**- when product breaks down, it will not leave behind heavy metals that are toxic to the soil above a standard level

Bioplastics and single-use compostable are often viewed as a feasible alternative for campuses who have access to composting operations. However, we encourage campus to abide by the waste hierarchy, to reduce and reuse before creating more waste that must be composted. Single-use compostable items still require resources and energy to be produced, packaged, and transported. Furthermore, many industrial composting facilities are opposed to large amounts of compostable plastics in their material, because the chemical makeup of #7 plastics can interfere with efficient decomposition of other materials

STEP 1: TARGETS LOCATIONS

While campus eateries are the common source of single-use disposable plastics on campus, there are many other source locations to take into account. Some are prime locations for single-use plastic reduction and some are hot spots of information from where we can continue to spread our message.

Promotional Areas:

Any place displaying school pride, like the campus bookstore or a sports venue, should also represent our campaign. Talking to campus vendors about selling reusable drinkware, like water bottles and coffee thermos; ask that cashiers and other store staff be trained to first ask customers if they need a plastic bag for their purchase, rather than offering it automatically. Look into the feasibility of installing water bottle filling stations**. Other ideas include**:

- not automatically offering straws for drinks, napkins, and other concessionary products at sporting events

- selling reusable bags at the bookstore with our campus logo

Residence Halls:

Residence halls are a prime location for targeting a large audience of potential plastic users on campus. In order for this to be successful, students need some means of utilizing plastic alternatives, especially those that already exist within dorm locations. For example, highlight existing water fountains and sinks in the building to sway students from purchasing bottled water.

Resident Advisors (RAs) are usually required to hold a certain number of programmed events each term. These events are a great opportunity to reinforce plastic-free habits and education. Reach out to residence hall staff to plan plastic-free program trainings for RAs at the beginning of each term.

Departments and Staff:

In addition to students, be sure that other members of campus are aware of plastic-free campus initiatives. If staff and faculty understand the effort to go plastic free, they can pass information onto students and campus visitors. Probably Plastic-free efforts can be incorporated into staff meetings, office operations, and class instruction so that these habits become a part of campus culture.

Events:

Events are a fun and inclusive way of extending the university's plastic-free initiatives to a larger audience. Events provide opportunities to:

- Recruit new volunteers and student groups to join in plastic-free initiatives
- Frame initiatives in a positive light, through fun and interactive activities
- Extend initiatives beyond everyday campus operations
- Advertise incentive programs that give discounts for bringing your own reusable items

Work with event planners to brainstorm procurement alternatives to purchasing single-use plastic materials and supplies. Brand these events as plastic-free in your invites, and make it explicit at the event itself. Connect with student clubs, groups and individuals coordinating events so they can join in and help cultivate a plastic-free culture.

Pre-Planning:

- Coordinate plastic-free purchasing by communicating with the caterer or food service provider that there should be no single-use plastic packaging for the food
- Buy in bulk or opt for food and materials that are packaged in paper, as long as we have the ability to compost or recycle the material
- Serve beverages fountain-style or out of out pitchers
- Provide reusable cutlery and serving utensils
- Opt for reusable decorations, like cloth table covers or woven placemats, or consult the art or theatre department for old set pieces (any plastic decor should be reused for future events)
- In our event invites, encourage guests to bring their own reusable water bottles and coffee mugs - if it is a picnic type event, attendees can even bring their own plates, bowls and utensils!

During:

- Set up clear signage for refillable water stations, water fountains, and waste bins
- Use fun displays to advertise the event as plastic-free

- Have interactive games around the plastic-free movement, with reusable prizes!
- Monitor bins throughout the event to ensure waste streams are properly separated (i.e. compost, recyclables, landfill trash). We like to refer to this job as "Trash Talkers"
- Train event staff to talk about plastic-free and the sorting of material in an encouraging way – they should not feel like they are educating, rather than policing

Clean-Up:

- Do a final sweep of bins to ensure waste streams are properly separated (i.e., compost, recyclables, landfill trash)
- Follow up on our material. Make sure each bin is picked up/ dropped off in the proper location in a timely manner after the event
- Recycle or reuse any plastic that did end up at the event, such as cellophane on catered food or plastic bags from an outside vendor. All of this has the potential to be washed and reused for future events!
- Debrief with our team and the event organizers to assess what went well and what could be improved

NEXT STEPS:

ALTERNATIVES TO SINGLE-USE PLASTICS

First, we talk about Education. If people know the problem with plastics, they will be a lot more likely to assist and accept the change. Refusal is next, addressing those pesky disposable items so common at to-go eateries. Our next mission is to replace those single-use plastic items with – and encourage the use of – reusable items. We cover bottles and fountains, bags, dishware and reusable containers, cutlery and vending machines, finishing up with an analysis of different styles of positive and negative reinforcement. Thinking longer term, we go on to discuss procurement policies for campus-wide change. Finally, cross-disciplinary alternatives acknowledge that a Zero Waste campus must be a plastic-free campus.

1. Education as an Alternative

Transitioning our campus to becoming free of single-use disposable plastics requires tangible and trackable goals. Keep in mind that many of our successes might take qualitative forms, and may be hard to measure. There may be too much pushback from our campus to officially ban single-use plastics; if this is the case, all is not lost! We can still EDUCATE the student body on the dangers of plastics, and their ability to make a direct positive impact by choosing to live their personal lives without them. For example, the dining hall may still give out straws but that doesn't mean people have to take them. When students are given the ability to choose, rather than having behaviour dictated to them, they feel more empowered! Furthermore, with the ability to choose, students come to better understand the initiatives in place and why they matter… this new attitude is more likely to be sustained beyond their time at the university'

2. Refusing Single-Use Items or Providing Upon Request

Dining areas and eateries are prime locations for complementary single-use items making them a primary source for generating waste on campus. Working with these areas can be a huge stride in our plastic-free efforts. Rather than offering napkins, straws, plastic bags, coffee sleeves, and ketchup packets in a free-for-all fashion, eateries can offer these items by request only. Better yet, many of these items can be displayed in a self-serve, bulk fashion.

3. Encouraging Reusable Items

Whether or not our campus is able to implement a ban on single-use plastics, It is important to highlight existing infrastructure that assists campus residents in living plastic-free. Post maps and signs around dorms highlighting existing water fountains for students to refill reusable drink containers at no cost. You might also look into making these fountains more reuse-compatible with special gooseneck spouts for more efficient bottle filling. These retrofitted fountains often referred to as "hydration stations" can improve perceptions around drinking free, local water.

4. Alternatives Through Procurement

A ban prohibits a product or material from being purchased, sold, or used on campus. Once incorporated into campus policy through a ban, plastic-free initiatives will have more strength and stability. All campus vendors and contractors must abide by the language of the ban; this puts pressure on vendors working with major institutions like AUC campus to create plastic-free alternatives for the greater consumer population.

5. Cross-Disciplinary Alternatives

Plastic-free is just one component to overall campus waste reduction. Joining forces with other waste reduction initiatives on campus can strengthen our campaign. A plastic-free campus is by no means mutually exclusive from sustainability initiatives concerning food recovery and hard-to-recycle materials.

Prioritize Local

Sourcing locally for food and other items reduces the need for extensive packaging, cuts carbon emissions associated with transportation, and allows for more opportunity to negotiate sustainable alternatives with vendors.

Recycling

An efficient recycling infrastructure is important for managing any plastics that do end up on campus. By recycling plastics, products get a chance to become something else, making it not quite single-use. Try to raise awareness around campus recycling operations participation rates among students. We might make our Plastic Audit a part of a larger campus Waste Audit to gauge all of the different types of waste materials generated on campus and how they are being disposed of.

Composting

Switching to compostable to-go ware and packaging is a great first step but it must come along with a composting system that can handle not only the material but the volume produced.

Campaigning

There are a ton of resources both on and beyond campus that we can utilize to spread the word for our project or campaign. Collaborate with our advisor, or equivalent project "champion", about how to reach out to local, regional, national, and international groups who are implementing plastic-free initiatives on a larger scale. Support in all shapes and sizes is important - augment the impact of students in numbers with a shout out from campus staff and faculty, community leaders and organizers, and non-profit advocates!

Advertise our Campaign!

Signage and Flyering

- Use different types of font, bolding or underlining important words, to guide the reader's eyes and to break up the text

- Keep it short and simple. Anyone and everyone should be able to get the message with just a quick glance

- Use images to draw attention and help convey information

- Create a memorable logo or slogan for a campaign

- Use numbers on our visual - they can be powerful for putting things into perspective

- Signs should be at eye-level so students can't miss them

- Get help from art and graphic design students!

Social Media Platforms

Social media is a powerful way to spread the word about our program. We recommend creating a Facebook page and Twitter handle for your plastic-free campaign and projects. Perhaps designate this task to a single person on our campaign team. Work with our Campus Coordinator to utilize PLAN's national media presence in advertising our campaign!

Making Plastic-Free a Positive Experience

It's really important that the students of our campus leave having had a positive experience with plastic-free initiatives. The goal is not to burden individuals by making it difficult to follow these initiatives. Reducing plastic use is important, and the goal is for students to realize that being plastic-free is possible, easy, affordable, and can be done without missing out on anything.

Educating Visitors

Educating visitors is not an obstacle, but an opportunity! Chances are that our university rents or donates space to community and private groups for events, such as conferences or summer camps. These visitors are likely unaware of campus plastic policies and initiatives. Work with whomever on our campus maintains communication with these types of groups, such as Admissions, Conference Services, or Orientation Staff, to ensure that the best effort to inform people of our university's policies is communicated before the visit. This also includes educating guest speakers and performers. To make it easier for speakers, performers, and other traveling individuals or groups to comply with our campus policies, offer them advice from the Plastic Pollution Coalition's one-sheet on "Touring Plastic Free", available in the Plastic-Free folder in our Google drive. University tours are another major avenue to convey campus practices. Talk with the department in charge of campus tours about training orientation guides to be able to effectively explain the plastic-free initiatives our campus has adopted.

Maintaining the Importance of Recycling

Recall any waste or plastic audits we performed in the beginning stages of our project or campaign. We may have found that a lot of students throw away recyclable materials. This often happens with lack of education regarding recycling infrastructure on campus. It might also be caused by inadequate recycling infrastructure to begin with: if recycling bins are not in close-enough range to a trash can, some people may not make the extra effort to distinguish where they are throwing away their waste.

Going plastic-free won't happen all at once, so continue to give attention to recycling infrastructure and participation on campus. Be sure that bins for all different waste streams are present at disposal areas, and are clearly marked and distinguishable. We also may have found in our audit that there is a significant amount of plastic from off-campus sources. It is important to continue education of proper disposal of these items, as they will inevitably enter campus from time to time.

Finally, being plastic-free does not mean disregarding recycling entirely. Even with a reduction of single-use plastics, recycling can still serve as an appropriate disposal method for glass, aluminium and more difficult to dispose of plastic products.

Department of Science & Technology & Renewable Energy

Chandigarh Administration

Paryavaran Bhawan,1st Floor, Sector-19B, Madhya Marg, Chandigarh

Tel.: +91 172-2703982 Fax: +91 172-2703968

FORMAT FOR SUBMISSION OF RESEARCH PROPOSAL

1	Title of the Project	**Integrated Video Surveillance and Monitoring System at Roadside Traffic Area to Identify the Stolen Vehicles**
2	Name and complete address of Principal Investigator including mobile number	Prof. (Dr.) Surendra Rahamatkar Dean-Faculty of Engineering & Technology, Director - Amity School of Engineering & Technology Amity University- Chhattisgarh, Manth (Kharora), Tilda, Raipur -493225. Mob: 9011794586, email: srahamatkar@rpr.amity.edu
3	Name and complete address of Co-Investigator (s) (preferably not more than two)	Nand Kishore Sharma Research Scholar (Computer Sc. & Engineering) Amity School of Engineering & Technology Amity University- Chhattisgarh, Manth (Kharora), Tilda, Raipur -493225. email: nand.sharma1@student.amity.edu
4	Detailed objectives /aims and Brief methodology of the project	Intelligent Surveillance is one of the main application of Smart City Project, in which the CCTV cameras are assembled where security matters. Thus, a modern surveillance system encompasses image acquisition devices and video acquisition devices to gather real-time information from the nearby roadside environment for surveillance such as Vehicle Identification entered in critical areas, Suspect Identification etc. As an Integration of Intelligent Traffic Management System, goal of the proposed model is to provide the Solution for Intelligent Surveillance System and to achieve this goal the following objectives are proposed to be implemented: - 1. **Designing of effective model for Car Vehicle Object Detection at Roadside Environment**. The image / video acquisition device will be responsible to capture the highway or roadside scenes. These data will be captured at traffic signal points where vehicle stops for some small amount of time and when vehicles are running at highways or roadside those may be captured by the cameras. The Proposed model will detect the vehicle as an object from the Image or Video Data captured by the devices and the detected object will be processed further by the Intelligent Surveillance System. 2. **Identification of important attributes of the Vehicle.** Once the Object is detected, the model will detect its attributes such as Number Plate, Color and Speed (if vehicle is running) of the vehicle.

		All these captured attributes will be used for vehicle identification purpose. **3. Vehicle Re-Identification through vehicle attributes.** For any vehicle, their license plates according to the hot listed categories like "Wanted", "Suspicious", "Stolen", stored in the police data base to track the vehicle. The attributes of the captured vehicle will be further used for verification with the hot listed category of the vehicles. **Brief Methodology:** In case if the vehicle has stolen, the speed of vehicle would be very high on highways and also on roadside, this high-speed vehicle will be considered under the suspect category and be used for further processing for vehicle identification purposes. The model will work in two stages- <u>First stage-</u> the image/ video acquisition device will capture the roadside scene, and model will detect the object from the streamed data. <u>Second Stage-</u> Model will detect the speed of the vehicle. If the speed of vehicle will be found high as compare to the average speed of the others vehicle on the same location, then it's another attribute i.e. Number Plate and Color will be verified from the database of stolen vehicle.
5	Name of Specialist, if any, who has been consulted for the proposed project	Prof. (Dr.) Surendra Rahamatkar
6	Name of other institution(s) involved in the project and brief details of involvement	NA
7	Whether the project is related to the problems of area of U.T., Chandigarh? If so, how?	As per the proposals invited for Financial Assistance for Short Term Research Studies by Department of Science & Technology & Renewable Energy Chandigarh Administration, among the area of research **Traffic Control and Parking Management** is one of them. The Proposed project for Surveillance System belongs to this category. As the data available on http://chandigarhpolice.gov.in/01-01-2019.htm total auto theft cases registered from 01.01.2019 to 31.12.2019 are 908 where 616 cases found registered for Auto theft. And continuation on http://chandigarhpolice.gov.in/01-01-2020.htm data found of theft cases is 281 from 01.01.2020 to 30.06.2020. Hence proposed projects found suitable to deal with such situation.
8	Whether in your view a similar type of project has been or is being launched in India elsewhere? If so, brief details thereof	In many cities Intelligent Traffic Management System is existed to detect the Red-Light Violation Detection, and for Automatic Number Plate Recognition. The Surveillance system is implemented manually thus Automatic or Semi-Automatic Surveillance System needs to be implemented.
9	Whether the project has been approved by the	Yes, the project proposal is approved by Standing Committee of the University.

	institute's research committee/ any other appropriate committee of the institute? Details thereof	
10	Name and address of three References	1. Dr. Rajendra Kumar Pandey, Vice Chancellor, Amity University Chhattisgarh, email: vcauc@rpr.amity.edu 2. Dr. Abhishek Singh Rathore, Associate Professor, Shri Vaishnav Vidyapeeth Vishwavidyalaya, Indore, email: abhishekatujjain@gmail.com 3. Mr. Paras Sharma, Project Head and ITMS Expert, Ujjain Smart City Project, email: paras.sharma@technosysgroup.com
11	Duration of the project	01 Year
12	Detailed financial involvement	1. **INR. 1,50,000/-** Apx. (GPU Based System (Laptop / Computer System), Min 16 GB RAM with Graphics(GPU): NVIDIA 2070/2080 (8GB), Processing(CPU): Intel i7-8750H (6 cores, 16x PCI-e lanes), RAM: 16 GB to 32GB, Storage: Up to 1TB NVME SSD (4-5x faster than normal SSD)) 2. **INR 10,000/-** Apx. External Storage Device + Softwares 3. **INR 25,000/-** Apx. Project Overhead Charges. 4. **INR 25,000/-** Traveling Expenditure 5. **INR 25,000/-** contingency
	Recurring	**INR 50,000/- Only** (INR 25,000/- Traveling Expenditure/ INR 25,000/- contingency)
	Non recurring	**INR 1,85,000/- Only** (INR 150,00/-GPU based Laptop/ INR 10,000/- External Storage Device & Softwares/ INR 25,000/- Apx. Project Overhead Charges)
	Total	**INR 2,35,000/- (Rupees Two Lacs Thirty Five Thousands only)**
13	Details of earlier project(s), if any, sanctioned by this Department i) Title of the Project ii) Sanction No. and Date iii) Duration iv) Date & No. vide which Final report submitted to this Department v) Whether Utilization Certificate & Statement of Expenditure have been submitted or not? If not, reasons thereof	------------------------NA-----------------------
14	Any other relevant Information	This proposed project is a part and subarea of the ongoing Research work of Research Scholar- Nand Kishore Sharma towards his PhD research study under the Supervision of Prof. (Dr.) Surendra Rahamatkar. The Inventors has filed the Patent Application on this Research Area (Patent Application Number: 202011034546, date of filing: 11.08.2020)

CERTIFICATE

Date: 14th August 2020

This is to certify that

I. All basic and administrative facilities available in the University will be provided to the Investigator(s).

II. It is, further certified that no financial assistance is sought from any other agency/sources for this proposal.

III. It is certified that the project / proposal does not require clearance from the Ethics Committee of the Institute

IV. The undersigned also agrees to abide by the terms and conditions of the grant set forth by the Department of Science & Technology & Renewable Energy, Chandigarh Administration, including timely submission of Audited Statement of Accounts, Utilization Certificate as per GFR, Final Report etc.

Principal Investigator
Prof. (Dr.) Surendra Rahamatkar

Co- Investigator
Nand Kishore Sharma

Head of Department
Prof. (Dr.) Surendra Rahamatkar
Dean-Faculty of Engineering & Technology,
Director - Amity School of Engineering & Technology

Head of Institution
Prof. Rajendra Kumar Pandey
Vice Chancellor,
Amity University- Chhattisgarh, Raipur.

Amity University Chhattisgarh Raipur

Approval of Standing Committee

Date: 14th August 2020

This is to certify that Standing Committee of the University constituted to review the Project Proposals has reviewed the Project Proposal of tile **"Integrated Video Surveillance and Monitoring System at Roadside Traffic Area to Identify the Stolen Vehicles"** prepared by Prof. (Dr.) Surendra Rahamatkar, Professor (CSE) & Director (PI) and Mr. Nand Kishore Sharma, PhD (CSE) Research Scholar (Co-PI) to be submitted to the Department of Science & Technology & Renewable Energy, Chandigarh Administration and recommended the said project proposal for submission.

Chairman
Standing Committee

Amity University Chhattisgarh Raipur

CHECKLIST FOR SUBMISSION OF THE RESEARCH PROPOSALS

To avoid the rejection of the proposal project proponents are requested to ensure the following: -

1	Correct and recent format (8 set, one original and 7 copies)	√
2	Soft copy (both in scanned pdf and word format) of the proposal (either in a CD or through email at dstchandigarh17@gmail.com) submitted	√
3	All the columns of the format are filled, and none is left blank (where a field is not relevant please write NA).	√
4	Copy of approval by the institute's research committee/ any other appropriate committee of the institute	√
5	Where the PIs and CIs are not from the same institute, Clearance/permission/recommendation from the institute of the Co-Investigator/s	NA
6	Copy of ethical clearance (wherever required) or undertaking that the same is not required	NA
7	Certificate by the Investigator (s) / Head of the Institution	√
8	Details of all the previous projects have been provided	NA

GUIDELINES FOR FORMULATION OF RESEARCH PROPOSAL

1. The proposal in the enclosed format in '8' set (one original and 7 copies) is to be submitted along-with its soft copy.
2. The proposal should be relevant to the area of UT Chandigarh and may not override the objectives contained in the proposals already sanctioned by the Chandigarh Administration.
3. The proposal should be feasible to be concluded once for all.
4. Only provisions for that equipment should be demanded which is of utmost necessity for the research project and which is not available in the institution concerned.
5. The proposal, preferably, may be of short duration i.e. for one year only.
6. A new proposal from the Principal Investigator who has already in hand a project approved from the Chandigarh Administration, Department of Science & Technology & Renewable Energy (DST&RE), will not be considered.
7. Each proposal will have a minimum of one and preferably not more than two Coinvestigator in addition to the Principal/ Chief Investigator.
8. No provision for staff like social workers, field workers, lab attendant etc. will be considered.
9. Any Principal Investigator, who has earlier worked in a Research Project, funded by this Department as Principal Investigator/ Co- Investigator, and the Accounts of the Projects are not settled, will not be considered.

THE RESEARCH SCHEMES BASED ON THE FOLLOWING POINTS WILL BE PREFERRED

I. Communicable diseases as related to UT Chandigarh viz. Water Borne Diseases and their management.

II. Epidemiology of Non-Communicable Diseases and Methods of their Control.

III. Water Proofing of buildings, Rain Water Harvesting.

IV. Pollution Measurements and Prevention.

V. Traffic Control and Parking Management.

VI. Cost effective building Materials.

VII. Processing and Preservation of Food/ fruits.

VIII. Horticultural Development.

IX. Alternate Sources of Energy and Energy Conservation.

X. Biotechnology - Medical & Health.

T&Cs FOR THE UTILIZATION OF FUNDS RELEASED TO THE INSTITUTIONS FOR THE PROJECTS SANCTIONED BY THE CHANDIGARH ADMINISTRATION, DEPARTMENT OF SCIENCE & TECHNOLOGY & RENEWABLE ENERGY.

1. The funds will be utilized within the prescribed period and for the purpose for which these are sanctioned.

2. The work and Accounts Books of the Grantee Institution shall be presented for inspection to the Director, DST&RE, Chandigarh Administration, or such other Officer as may be appointed by him in this behalf, and those instructions for better workmanship or accountancy issued by the aforesaid authority shall be complied with by the grantee.

3. The grantee shall submit the project accounts duly audited on the completion of the project to the Department.

4. On the completion of the project any unspent / unutilized balance out of the funds shall be refunded by the grantee to the Chandigarh Administration forthwith.

5. The project will become operative with effect from the date on which the sanction / grant is received by the Institute. The date will be intimated by the Institute to the DST&RE. It will, in no case, be later than 15 days after the receipt of the funds by the Institute.

6. The Chandigarh Administration would have no liability whatsoever for the absorption of staff after the completion of the project.

7. That the institution shall associate with the Administration whenever required.

8. That all equipments purchased or acquired with or with the aid of the said funds for the purpose shall remain the property of the Chandigarh Administration and shall be held by the grantee as trustee of the Administration and no part of the proceeds of the said funds will be sold or otherwise transferred or disposed off without the consent of the Administration, and if so required by the Administration, the grantee shall at his own cost insure all such equipments or things against fire.

9. That the grantee shall submit Quarterly Progress Reports of the work done on the Project to the Director, DST&RE, Chandigarh Administration. On completion of the project, the Principal Investigator will submit 5 copies of the Project Report on the work done on the project, along with a soft copy, to the Department.

10. The grantee or his co-workers or any person connected with the institutions to which the project is entrusted shall not publish the result of the Research / Data of the Project in any of the India or Foreign Journals or in any other way without prior permission of the Administration.

11. The grantee shall not commercially exploit the results of the data in any manner whatsoever, without prior permission on the Administration.

12. The Administration shall have the exclusive right to determine whether any copy rights should be obtained for the results of the project or whether any commercial use of the results of the data should be made.

13. The Administration reserves the right to terminate the funds at any stage, if it is satisfied that the funds have not been or are not being properly utilized for the purpose for which these were sanctioned or that the progress of the work is not satisfactory. On cancellation, the amount of expenditure already incurred, along with the unspent portion of the funds shall be remitted by the grantee within one month to the Administration.

14. The grantee shall furnish an inventory of equipments purchased along with the progress report. The inventory should give the description of equipments, its cost, date of purchase and the names of the supplier.

15. The Administration shall reserve the right to transfer any equipment or stores purchased from the funds to any other department or institution of U.T., Chandigarh.

16. That if the said funds or any part thereof is not used for the purpose mentioned here in or any of the above condition is not complied with by the grantee, then without prejudice to its rights, civil or criminal or otherwise, the Administration shall

be entitled to recover forthwith the amount of the funds together with Bank Interest prevalent at that time from the date of funds transferred by the DST&RE, Chandigarh Administration.

17. That if the Administration is satisfied that the whole amount of funds or any part thereof has been obtained by the grantee by misrepresentation as to an essential fact or by furnishing of false information, or at any time it comes to the notice of the Administration that the grantee was not eligible to the said amount of funds or any part thereof, the Administration may claim refund of the said amount of grant or any part thereof with interest from grantee at the Bank Rate prevalent at the time of recovery, after giving him proper opportunity to be heard, and on such claim being made the grantee shall forthwith pay the amount claimed.

18. The Institute may not entrust the implementation of the work for which the grant is being sanctioned to another Institution and divert the grant receipts as assistance to the latter institution. In case the Institute itself is not in a position to execute or complete the project, it may be required to refund forthwith to the DST&RE, Chandigarh Administration the entire amount of grants-in-aid received by it.

19. If the Principal Investigator to whom a grant for a project has been sanctioned wishes to leave the Institution where the project is based, the institute / Investigator will inform the same to the DST&RE and, in consultation with the DST&RE, the institute shall evolve steps to ensure successful completion of the Project before relieving the Principal Investigator.

20. That all disputes and differences arising out, or in any way touching or concerning these funds, whatsoever, shall be referred to the sole arbitration i.e. Secretary Science & Technology & Renewable Energy, Chandigarh Administration, acting as such at the time of reference. There will be no objection to such appointment that the Arbitrator so appointed is an employee of the Administration and that he had to deal with the latter to which this sanction relates in the course of his duties, and as an employee of the Administration he has expressed views on all or any of the matters in dispute or difference. The award of such Arbitrator shall be final and binding on both the parties.

21. Any of the terms and conditions set herein may be added / deleted / altered / relaxed at the discretion of the Secretary, DST&RE, Chandigarh Administration.