




Modelling potentially suitable lac cultivation zones of *Butea monosperma* to promote livelihood security in rural India

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Abstract

The present paper highlights the importance of lac cultivation through *Butea monosperma*. We have modelled the suitable habitat of major lac host *B. monosperma* using MAXENT for the current and future climatic scenarios (RCPs 2.6, 4.5, 6.0 and 8.5). The study suggested the dominance of suitable habitats of *B. monosperma* in central-eastern to eastern and southern parts of the country. Temperature seasonality (Bio_4) was the most significant bioclimatic variable in regulating the distribution of *B. monosperma* followed by elevation and annual precipitation (Bio_13). The projection for the year 2050 suggested the habitat shift towards the eastern and southern parts. The study indicated the major habitat of *B. monosperma* continued to exist in the Chotanagpur plateau in eastern India. The model predicted approximately a 9–13% decrease in the overall potential habitat of *B. monosperma* by 2050, and the distribution of species would be nearly extinct from the northern and western parts. Presently, only the 5% lac host trees are being utilised for lac cultivation, and the study suggested that conservation and promotion of *B. monosperma* on projected suitable habitats and even by utilising 25% of resources, the lac production may jump manifold catering to global demand, rural economy and employment and shall contribute towards ‘Self Reliant India’.

Keywords *B. monosperma* · Climate · Lac cultivation · Livelihood security · Maxent

Introduction

Forests provide a wide range of ecosystem goods and services to the inhabitants (Gosain et al. 2015). The changing climatic conditions have adversely impacted the forest ecosystems through altered habitat distribution of plant species (Walther et al. 2002), reduced productivity, changes in species composition, and plant diversity (Morin et al. 2018). Forest ecosystems occupy a substantial part (31%) of the Earth’s land surface (FAO and UNEP 2020), while tropical forests cover merely 7% of the Earth’s land surface and harbour more than half of the world’s species (Wilson 1988). These tropical forests are highly threatened by human activities (Htun et al. 2011) and forest clearing would remove 85% of the species inhabited in it (Baboo et al. 2017; Jhariya et al. 2012; Kittur et al. 2014). Tropical forest observed continuous loss of more than one higher plant species per day (Myers 1990) through the disappearance of 20 ha forests and destruction of more than 1800 populations per hour (Hughes et al. 1997). The rate of species loss is 3–8 times higher than the rate of species extinction due to natural and

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Abstract

The status of the tribal domestic workers in Jharkhand is explored. It is evident that large numbers of tribal women are engaged as domestic workers inside and outside of the state, and the sector provides a large chunk of employment apart from the cultivation and agricultural sector. The data show differential engagement in the sector by age, urban-rural location, gender, and tribe. © 2021 Economic and Political Weekly. All rights reserved.

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Influence of Super Cyclone “Amphan” in the Indian Subcontinent amid COVID-19 Pandemic

Shubham Kumar¹ · Preet Lal¹ · Amit Kumar¹

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Abstract

Tropical cyclone “Amphan” developed as a super cyclone on 19 May 2020 and caused severe impact on the landmass with very high torrential precipitation ($>250 \text{ mm day}^{-1}$), and extremely high wind speed ($>150 \text{ km h}^{-1}$) after landfall on 20 May 2020. The tropical cyclone Amphan largely affected agricultural land (78.2%) and forest, including mangroves (10.8%) in eastern India and Bangladesh. The built-up area over the trajectory of the cyclone and its proximity, including eastern parts of the Kolkata metropolitan area, was considerably affected by the cyclone due to the high population density and poor structural and community planning. Although the regions with close proximities to cyclones’ trajectory (2033 km^2 area under $<2 \text{ km}$ proximity) were affected severely, the presence of mangrove forest in Sundarban substantially reduced the magnitude of the tropical cyclone. A considerable decrease ($\sim 30\%$) in aerosol optical depth (AOD) in April–May 2020 as compared to that in 2019 is considered one of the major causes of the development of the warm pool and cyclogenesis in the Bay of Bengal. The number of COVID-19 cases increased by $\sim 70\%$ in the post-cyclonic period (29 May 2020) compared to that in the pre-cyclonic period (19 May 2020) illustrating the impact of the cyclonic hazard.

Keywords Tropical cyclone · Precipitation · AOD · SST · Mangrove · Bay of Bengal · COVID-19

1 Introduction

The Indian Ocean experienced the devastating impact of super cyclone *Amphan* during 16 May–22 May 2020. Amphan was the first super cyclonic storm in the Bay of Bengal having a very high wind speed ($>200 \text{ km h}^{-1}$) since the 1999 Odisha cyclone [1]. It caused the loss of human lives (72 persons in India and 12 in Bangladesh), high destruction, and damage to public property, which cost ~ 1 lakh crore INR (13.46 billion USD) and the destruction of around 1 million houses as per the initial reports of damage assessment [4].

A tropical cyclone is characterized by intense tropical storms that originate in a warm tropical ocean with low atmospheric pressure, high wind, and heavy precipitations [33]. The intensity of a tropical cyclone is measured based on its

damage on the landmass after landfall [20, 34]. Globally, the Indian subcontinent is considered one of the worst cyclone-affected parts in the Indian ocean region due to the shallow depth and the warm pool phenomenon (sea surface temperature (SST) $\sim > 28 \text{ }^\circ\text{C}$) [14], where the Bay of Bengal (BoB) is more prone to cyclone genesis [2] with an approximate ratio of 4:1 as compared to the Arabian Sea [11]. The Indian Ocean experiences an average of 5–6 cyclonic activities in a year [32], affecting the coastal regions and interior parts with different intensities [10]. The settlements in the coastal areas, primarily major cities, are affected by not only cyclones but also various other natural disasters including sea-level rise [31], storm surge [8], and flood inundation [15, 23, 24].

The occurrence of any natural hazards during the COVID-19 pandemic may have catastrophic and cascading implications [29]. The co-occurrence of hazardous natural (cyclones) and a biological origin (COVID-19) leads to severe crisis situations and challenges the resilience of societies and systems [30]. The COVID-19 pandemic that occurred in December 2019 has created havoc around the globe due to an increase in the number of cases and deaths [22]. The virus outbreak has been spreading through human-to-human transmission [5]. Globally, there were around 148,859,866 confirmed cases

Shubham Kumar and Preet Lal contributed equally and can be treated as first authors.

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Article

Future Food Sustainability Can Be Traced Back into Local People's Socio-Cultural Roots in Uttarakhand Himalaya, India

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Abstract: Sustainable food system ensures adequate and safe food supply in an eco-friendly manner. We assessed food sustainability perception and practices of local community through structured interviews in sub-alpine settlements of Uttarakhand Himalaya. Major perceived challenges towards food sustainability were identified using Rank-Based Quotient analysis. Association with various socio-demographic factors (e.g., age, gender, education, socio-economy, and socio-culture) was tested. An overall neutral perception (mean score 2.9) and moderately sustainable practices (mean score 3.1) were observed. Respondents with higher socio-cultural score showed more sustainable food sourcing practices and more positive social and economic sustainability perception, as well as higher participatory willingness. Female respondents were more dependent on sustainable food sources than the males. Education level influenced food quality choice. People identified higher food production cost as major economic constraint; while small landholdings and labor migration were main social challenges. Land and water management issues and climate uncertainty were the major environmental constraints. Socio-cultural exposure played significant role in ranking these sustainability constraints. We encourage direct involvement of socio-culturally active people and conducting extensive outreach programs for future sustainable local food system in vulnerable Himalayan valleys.

Keywords: sustainable food system; public perception; socio-demographic factors; socio-culture; food sustainability constraints



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1. Introduction

Our modern food system is under constant scrutiny of 'sustainability' criteria with increasing complexities in our lifestyle and socio-economic standards. A sustainable food system (SFS) delivers food security and nutrition for all in such a way that the economic, social, and environmental bases to generate food security for future generations are not compromised [1]. Food security truly exist only when all people at all times have physical, social, and economic access to food of sufficient quantity and quality to meet their dietary needs for an active and healthy life coupled with a sanitary environment [2]. Several ecological, environmental and climate change-related crises (e.g., population growth, resource scarcity, biodiversity loss, pollution, greenhouse gas emissions, etc.) threaten global food security and sustainability [3–7]. The situation has been aggravated in the recent COVID-hit world [8,9]. Increasing production efficiency, restraining consumption demand, and improving governance are some of the major strategies for creating food sustainability [7].

A typical food system involves various stages, like production, post-production, supply chain, consumer's food sourcing, choice of quality, consumption pattern, management of food waste, governance, and policy decisions. Addressing environmental, economic,



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Optimal hydropower generation of Maithon multi-purpose reservoir system

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Abstract

The present study focuses on optimizing the hydropower generation capacity of a multi-purpose reservoir system considering various constraints, including reservoir water mass balance, minimization of sediment, maximum and minimum reservoir water storage, maximum and minimum reservoir water releases, reservoir water drawdown levels, reservoir overflows, maximum flood zone space, and maximum and minimum storage constraints under 50%, 70% and 90% dependable inflow conditions. The focus is the Maithon multi-purpose reservoir system located at Maithon, a distance of 40.2 km from Dhanbad, the coal capital of India, in the State of Jharkhand. The study results indicate the derived policy is capable of producing maximum annual hydropower of 146,519.48 MWh/year for a 50% dependable inflow condition, 105,512.02 MWh/year for a 70% dependable inflow condition and 58,924.38 MWh/year for a 90% dependable inflow condition, compared to the existing hydropower generation of 129,428.4 MWh/year (average of last 10 years). A trade-off between reservoir release

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Temporary reduction in air pollution due to anthropogenic activity switch-off during COVID-19 lockdown in northern parts of India

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Abstract

Due to fast and deadly spread of corona virus (COVID-19), the Government of India implemented lockdown in the entire country from 25 April 2020. So, we studied the differences in the air quality index (AQI) of Delhi (DTU, Okhla and Patparganj), Haryana (Jind, Palwal and Hisar) and Uttar Pradesh (Agra, Kanpur and Greater Noida) from 17 February 2020 to 4 May 2020. The AQI was calculated by combination of individual sub-indices of seven pollutants, namely PM_{2.5}, PM₁₀, NO₂, NH₃, SO₂, CO and O₃, collected from the Central Pollution Control Board website. The AQI has improved by up to 30–46.67% after lockdown. The AQI slope values – 1.87, – 1.70 and – 1.35 were reported for Delhi, – 1.11, – 1.31 and – 1.04 were observed for Haryana and – 1.48, – 1.79 and – 1.78 were found for Uttar Pradesh (UP), which may be attributed to limited access of transportation and industrial facilities due to lockdown. The ozone (O₃) concentration was high at Delhi because of lesser greenery as compared to UP and Haryana, which provides higher atmospheric temperature favourable for O₃ formation. The air mass back trajectory (AMBT) analysis reveals the contribution of air mass from Europe, Africa and Gulf countries as well as local emissions from Indo-Gangetic Plain, Madhya Pradesh and Maharashtra states of India.

Keywords AQI · Lockdown · CPCB · Pollutants · Air mass back trajectory

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Present and future projections of heatwave hazard-risk over India: A regional earth system model assessment

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ABSTRACT

The heatwave is a disastrous hazard having significant impacts on health and society. This study analyses the heatwave hazards and risk for India's current and future scenarios using socioeconomic vulnerability and temperature datasets during the summer (April–June) season. The Census of India (CoI) 2011 datasets were considered to assess current vulnerability and projected from the SocioEconomic Data And Application Center (SEDAC) population at Shared Socioeconomic Pathway (SSP) 4 for future vulnerability. Whereas IMD temperature data used for hazard assessment for the present scenario (1958–2005) while projected temperature data from regional earth system model REMO-OASIS-MPIOM (ROM) were used for the future (2006–2099) scenario. The study exhibited the most hazardous, vulnerable, and risk-prone regions identified as the south-eastern coast and Indo-Gangetic plains and some populous districts with metropolitan regions (Mumbai, Delhi, and Kolkata) under the current scenario. The coupled model ROM has efficiently captured the critical districts with higher and lower risk, showing its future projection capability. The study highlighted that the heatwave hazard-risk would significantly worsen in future scenarios in all districts under enhanced global warming and largely affecting the districts in the eastern and middle Indo-Gangetic plains and Malabar region. The present study will provide sufficient insights into designing mitigation strategies and future adaptive planning for the heatwave risk, which is one of the targets under Sustainable Development Goal 13 (Goal 13: Climate Action).

1. Introduction

Heatwaves pose an evolving natural hazard of excessive heat, whose intensity, frequency, and duration are increasing due to the combined impacts of the warming climate and escalated anthropogenic influences in the recent decades (Perkins and Alexander, 2013; Perkins-Kirkpatrick and Lewis, 2020). The heatwaves have affected not only humans but also other organisms and the economy. It has caused enormous loss of human lives worldwide, such as Europe's heatwave in 2003, which killed approx. 77,000 people (Robine et al., 2008), Russia, in 2010, killed ~55,000 people (Barriopedro et al., 2011; Otto et al., 2012). The risk due to heatwave disasters is one of the greatest threats to humans, which will rise further with the increase in temperature as projected to ~3–6 °C at the end of the century (IPCC, 2014). Considering its vast implications, the heatwave is one of the major variables cited in the Sustainable

Development Goals (SDG) under goal 13 (climate action), which aims to limit global warming to 1.5 °C and related threats due to heat extremes. Since it is already reported that the frequency, duration, and intensity of such events are expected to increase (IPCC, 2014; Mukherjee and Mishra, 2018; Rohini et al., 2019), it is essential to develop appropriate tools for identifying hazardous regions and associated risks to assess potential impacts on human health (Meehl and Tebaldi, 2004). According to the Intergovernmental Panel on Climate Change (IPCC, 2014), climate change risks are determined by climate extremes (the hazards) and society's exposure and vulnerability to these hazards. Though the SDG 13 limits the use of coals and other greenhouse gas emitters, the temperature increase is not yet under control. Therefore, the heatwave risk projection will help to identify the highest risk-prone zones and develop mitigation strategies. Also, one of the targets of SDG 13 is to strengthen resilience and improve the mitigation strategies due to climate-related

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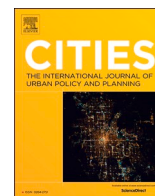
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Impacts of partial to complete COVID-19 lockdown on NO₂ and PM_{2.5} levels in major urban cities of Europe and USA

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ABSTRACT

SARS CoV-2 (COVID-19) coronavirus has been causing enormous suffering, death, and economic losses worldwide. There are rigorous containment measures on industries, non-essential business, transportation, and citizen mobility to check the spread. The lockdowns may have an advantageous impact on reducing the atmospheric pollutants. This study has analyzed the change in atmospheric pollutants, based on the Sentinel-5Ps and ground-station observed data during partial to complete lockdown period in 2020. Results revealed that the mean tropospheric NO₂ concentration substantially dropped in 2020 due to lockdown against the same period in 2019 by 18–40% over the major urban areas located in Europe (i.e. Madrid, Milan, Paris) and the USA (i.e. New York, Boston, and Springfield). Conversely, urban areas with partial to no lockdown measures (i.e. Warsaw, Pierre, Bismarck, and Lincoln) exhibited a relatively lower dropdown in mean NO₂ concentration (3 to 7.5%). The role of meteorological variability was found to be negligible. Nevertheless, the reduced levels of atmospheric pollutants were primarily attributed to the shutdown of vehicles, power plants, and industrial emissions. Improvement in air quality during COVID-19 may be temporary, but regulatory bodies should learn to reduce air pollution on a long-term basis concerning the trade-offs between the environment, society, and economic growth. The intersection of urban design, health, and environment should be addressed by policy-makers to protect public health and sustainable urban policies could be adopted to build urban resilience against any future emergencies.

1. Introduction

The severe acute respiratory syndrome Coronavirus 2 (SARS-CoV-2) is widely known as COVID-19, and its outbreak started from Wuhan, Hubei Province, China in late December 2019 (Lai et al., 2020; Lu et al., 2020). It has been rapidly spreading across the world and affected over 215 countries (Wang et al., 2020; Laxminarayan et al., 2020), with more than 34.5 million COVID-19 cases and 1.02 million deaths globally as of 2nd October 2020 (JHU, 2020). Epidemiological investigations reported that the pneumonia-like cases were originated in Wuhan and linked to the seafood, wild animal market, and known to be of zoonotic origin. As per the World Health Organization (WHO) and other latest studies, this virus transmits from human to human by direct contact in the form of tiny respiratory droplets (Carlos et al., 2020; Li et al., 2020; Wang et al., 2020). Global travel is one of the primary reasons for its worldwide

spread (Munster et al., 2020). The WHO declared COVID-19 as the latest Public Health Emergency of International Concern (PHEIC) on 30th January 2020, which follows H1N1 in 2009, Polio in 2014, Ebola in West Africa in 2014, Zika in 2016, and Ebola in the Democratic Republic of Congo in 2019. The COVID-19 pandemic has forced governments to declare 'lockdowns' in over 100 countries worldwide. As a result, economic activity has come to a standstill situation in many countries due to restrictions on industrial production, power plants, non-essential business, transport systems, institutes, offices, travel bans, and citizen mobility. Lockdown dates differed between countries but were mostly implemented in March 2020 except in Hubei, China (Table 1). The easing of containment measures mainly initiated from the 2nd week of May 2020 (Table 1).

Nitrogen dioxide (NO₂) is a key air pollutant that is emitted from both natural processes (e.g. lightning) and anthropogenic activities, such

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Removal of crystal violet by Cu-chitosan nano-biocomposite particles using Box–Behnken design

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ABSTRACT

Copper nanoparticles (CuNPs) impregnated biocomposites (Cu/chit-NBC) were prepared and characterized by the state-of-the-art analytical techniques. The CuNPs were in the average size ranges of 45.6–63.7 nm and 86.4 nm as confirmed by scanning electron microscopy and dynamic light scattering, respectively. To decolorize the crystal violet from the aqueous medium, fabricated Cu/chit-NBC was applied as an adsorbent. Box–Behnken design using three independent variables was adopted to optimize the Crystal Violet (CV) decolorization process. Under the optimum conditions of temperature 42.7 °C, pH 9.5, and 149.9 mg L⁻¹ dose of adsorbent, 99.7 ± 0.2% decolorization was observed. Cu/chit-NBC also showed a very high dye removal capacity in simulated industrial textile effluents of around 99.7 ± 0.2%. The CV decolorization was consistent with pseudo-second-order kinetics and best fitted with the Freundlich adsorption isotherm. The nature and the potential processes involved in interactions between the CV and the nano-bioadsorbents during discoloration have been discussed in this paper.

1. Introduction

Water resources are necessary for the survival and existence of human beings and are needed for other human needs, including but not limited to health, hygiene, food, energy, and economy. Water is polluted by the continuous release of chemicals, detergents, fertilizers, pesticides, heavy metals, textile dyes, etc. The water bodies contaminated with anionic and cationic dyes posed a threatening effect on the aquatic flora and fauna. Cationic dyes can strongly interact with the negatively charged cell membranes, so having more damaging effect than anionic dyes. Suffocations and frequent hypersensitivity are frequent subsequent of these dyes [46]. Crystal violet is frequently used for dye preparation in various textile, paper, nylon, leather, acrylic, wool, silk, and plastics-based industries. This water-soluble dye is placed under triarylmethane group having cationic nature. Hence, it is the need of mankind to explore more on the economical alternatives to cope up with these contaminants. Various researchers around the world are exploring the possibilities to deal with this emerging environmental problem. Conventional and non-conventional strategies for removing dyes from

the aqueous system have been adopted [10]. Wastewater treatment methods like membrane filtration, chemical coagulation, chemical oxidation, flocculation, photochemical degradation, electrochemical treatment, reverse osmosis, precipitation, ion exchange and adsorption etc. have been adopted to reduce the contamination load in effluents [25,51]. Amongst all the aforementioned methods, adsorption is the most efficient for the removal of contaminants from waste effluents one because of the low-cost, design and choice of sorbent materials involved in the process [11,50].

Biosorption methods have proved its efficacy as a most promising strategy to decontaminate the wastewater from the hazardous dyes. Decoloration of waste effluent by synthetic and natural flocculants has been widespread throughout the world [46]. Biopolymeric composites [56], bacteria, algae, fungi [35], agricultural-based activated carbons [1], cellulose-based waste, agricultural peels, and composts [41] are widely used adsorbent materials, particularly for the decolourization of waterbodies. The potential of bio-wastes like domestic, agricultural and biomass wastes as cheaper bio-adsorbents have also been explored [49]. Nanomaterials have emerged as the most promising adsorbents. Their

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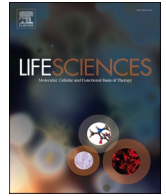
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Bcl-xL expression and regulation in the progression, recurrence, and cisplatin resistance of oral cancer

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ABSTRACT

Background: Bcl-xL is an anti-apoptotic molecule, but its role in the progression and recurrent/ drug-resistant oral squamous cell carcinoma (OSCC) is poorly understood.

Materials and methods: A total of one hundred twenty-five human OSCC tissue specimens including twenty-nine adjacent normals (AN), sixty-nine primary tumors (PT), twenty-seven recurrent chemoradiation resistance (RCRT) samples, and oral tongue SCC derived cisplatin-resistant (CisR SCC-4/-9) cells were used, for this study. Protein/mRNA expression levels of Bcl-xL and its regulation by ERK1/2, Stat-3, p53, NFκB, AP-1 (components: c-Jun, c-Fos, and Fra-2) molecules, and cell viability were measured by immunohistochemistry, Western blot, RT-PCR, and MTT analysis. Further, the individual and synergistic effects of Fra-2 (siRNA) and nimbolide were tested in CisR SCC-4/-9 cells.

Results: Progressive increase of Bcl-xL expression and its transcriptional-deregulation was observed with OSCC progression and resistance. Among all the possible upstream regulators of Bcl-xL, such as ERK1/2, Stat-3, p53, AP-1, and NFκB, the TF AP-1 ($r = 0.644$, $p = 0.0001$) showed maximum association with Bcl-xL mRNA expression. Though differential expression of AP-1 components were detected in OSCC specimens, with more striking positive-correction of c-Jun ($r = 0.381$, $p = 0.049$), c-Fos ($r = 0.139$, $p = 0.488$, ns) and Fra-2 ($r = 0.664$, $p = 0.0001$) with Bcl-xL expression observed stronger in RCRT tumor subgroup. Further, knockdown of Fra-2 and the application of plant-based phytochemical nimbolide decreased Bcl-xL expression and induced apoptosis in CisR SCC-4/-9 cells.

Conclusion: Collectively, we have demonstrated the role of Bcl-xL and AP-1 (Fra-2), causing OSCC progression and cisplatin resistance. Targeting Bcl-xL upstream pathway along with the application of nimbolide might be beneficial in eliminating drug-resistant OSCC.

1. Introduction

Oral cancer is one of the most common human malignancies and a threat to humankind [1]. Oral cancer can be of various cellular origins, but it mainly occurs in the epithelial cells of oral mucosa and is known as oral squamous cell carcinoma (OSCC). The incidence of OSCC in India and Southeast Asian countries is much higher than in the rest of the world [2,3]. A large fraction of cases are typically diagnosed in late stages and are commonly treated by chemoradiation therapy [4]. Although this treatment efficacy is conventional, accumulating data indicates, many of these tumor cells do not undertake apoptosis easily, and many of them become drug-resistant [5,6], leading to locoregional recurrence [7].

B-cell lymphoma-extra large (Bcl-xL) is a well-known anti-apoptotic protein molecule of the Bcl-2 family. Bcl-xL inhibits cytochrome-c release, and thus it is a significant component of the intrinsic apoptosis pathway [8,9]. The reduced Bcl-2 family or elevated Bax family proteins expression finally induces apoptosis. The balance between anti-/pro-apoptotic mediators is crucial for determining apoptosis evasion and tumorigenesis [10,11]. High expression of Bcl-xL was found associated with tumor progression or drug resistance [12–18]. Bcl-xL is also a critical component in the radiation resistance of OSCC [12]. The alteration of Bcl-2 and Bax has been reported recently by us. These molecules promote OSCC progression and drug resistance [5,6]. Though Bcl-xL is one of the essential molecules determining cell fate in OSCC and associated with drug resistance, its regulation and therapeutic

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Preparation and characterization of a copper oxide nanoparticle-supported red-mud catalyst for liquid phase oxidation of ethyl benzene to acetophenone

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Abstract

In this study, liquid phase oxidation of ethyl benzene to acetophenone was widely investigated using a new recyclable supported catalyst of CuO nanoparticles impregnated over activated red-mud (CuO_AARM). The catalyst was prepared using a hydrothermal reaction procedure. A catalytic conversion process was carried out in the presence of H₂O₂ as an oxidant. Material characterization was performed using various instrumentation techniques such as FTIR, TGA, XRD and TEM. The H₂-TPR results indicate the reducible properties of the catalyst at low temperatures, attributed to the presence of largely scattered small-sized CuO species on the support material. The progress of the catalytic reaction was found to follow the pseudo 1st order kinetics. The proposed mechanistic pathway, in an optimized geometrical structure, was found to favor the reaction via hydroperoxyl radical formation following an endergonic process, evident from the correction to Gibbs free energy. A selectivity of 74.0% is achieved with this catalyst in the oxidation of ethyl benzene to acetophenone. The synergy between the atomically

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Microwave-assisted biosynthesis of copper oxide nanoparticles using *Atalantia monophylla* (L.) leaf extracts and its biomedical applications

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Abstract

This study investigates the facile and rapid biosynthesis of copper oxide nanoparticles (AM-CuONP) using *Atalantia monophylla* leaves extract under microwave irradiation for its antimicrobial, antioxidant and anticancer applications. Optical and structural characterizations have confirmed the synthesis of spherical to rod-shaped phase pure AM-CuONP with an average particle size of ~23 nm. The antibacterial activity of AM-CuONP was higher with gram-positive bacteria compared to gram-negative bacteria. The antioxidant potential of AM-CuONP was reflected in the radical scavenging activities of 2,2'-diphenyl-1-picrylhydrazyl and 2,2'-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid in a concentration-dependent manner. Promising anticancer activity of AM-CuONP has been observed by killing ~80% of HeLa cells without affecting normal human embryonic kidney cells (HEK 293). Thus, the study demonstrated the potential of biosynthesized AM-CuONP for antibacterial, antioxidant and anticancer applications.

Keywords: *Atalantia monophylla*, copper oxide nanoparticles, antimicrobial, antioxidant, anticancer

1. Introduction

Nanotechnology is a highly multidisciplinary field of science and technology that is applied to the fabrication of materials at the nanoscale (typically 1–100 nm) for numerous applications. The synthesis of copper oxide nanoparticles via physico-chemical approaches are energy-intensive and needs hazardous chemicals [1,2]. Microwave-assisted green synthesis of various nanoparticles, including copper oxide, have been emerged as an eco-friendly approach. The microwave irradiation involves bipolarization and ionic conduction mechanisms for heating which makes it a fast, uniform, selective, and efficient compared to traditional heating techniques [3,4]. Microwave-irradiation also plays a key role in the fabrication of nanoparticles by inducing nucleation, formation, establishing equilibrium of chemical reaction as well as interrelated crystallization parameters [5–8]. Metal and

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Total synthesis of the proposed structure of Anti-TMV active tabasesquiterpene A

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ABSTRACT

The proposed structure of Tabasesquiterpene A, an illudalane type of sesquiterpene has been synthesized in twelve steps from 2-methoxy-4-methylbenzaldehyde in 40% overall yield. Triflic acid mediated intramolecular Freidel-Crafts acylation allows to develop the critical indanone moiety, a key intermediate of this synthesis. A careful *ortho*-selective formylation and subsequent Knoevenagel condensation to incorporate three carbon side chain, followed by reduction, formation of tricyclic lactone and DIBAL-H supported reduction of lactone to target were other key transformation involved. The NMR spectroscopic data of the synthetic sample differ from those of natural tabasesquiterpene A.

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1. Introduction

Nicotiana tabacum of the genus *Nicotiana*, native to the tropical Americas is a commercial crop of tobacco [1]. Apart from a stimulating agent, the herbs of *N. tabacum* have been used as an insecticide, anesthetic, diaphoretic, sedative, and emetic agent in Chinese folk medicine [2–4]. This herbaceous plant constitutes of diverse molecular scaffolds with remarkable biological activities, including anti-HIV-1, anti-TMV, and cytotoxicity [5]. In 2015, Shang et al. isolated a new sesquiterpene tabasesquiterpene A **1** (Fig. 1) with unprecedented structure from *Nicotiana tabacum* [6]. The architecture of **1** is similar to illudalane sesquiterpene, which is commonly found in fungi and ferns [7,8]. Unlikely, tabasesquiterpene A **1** has a *gem*-dimethylated indane core with hydroxy propyl side chain, whereas the illudalanes comprise of hydroxy ethyl side chain. Additionally, **1** exhibited potential anti-TMV activity with good inhibition rates. Shang et al. proposed the structure of **1** based on an extensive spectroscopic studies such as UV, HRMS, 1D NMR and 2D NMR (¹H–¹H COSY, HMBC). Apart from the biological activity, the polysubstituted benzene core represents tabasesquiterpene A **1** as a synthetic target for studies. In addition, the interesting part of **1** is a methyl group at C-6, hydroxypropyl side chain at C-5 of *gem*-dimethylated indane core. Generating this indane core from aromatic compound with poor directing groups

and propyl chain regioselectively would be a challenging part associated with this synthesis. In the last two decades, remarkable works have been reported in the synthesis of illudalane sesquiterpenes [9]. In our ongoing endeavour to synthesize new biologically active natural products, we herein discuss our effort to synthesize target **1**.

2. Results and discussion

Retrosynthetic plan for synthesis of **1** is briefly outlined in Scheme 1. After careful evaluation of the structural features, we envisaged that the final compound could be obtained from the tricyclic lactone **2** by DIBAL-H mediated reduction. The precursor **2** could be easily developed from the intermediate **3** via *ortho*-formylation, methylation, Knoevenagel condensation followed by hydrogenation and demethylation. Phenolic indane **3** could be accessible from the indanone **4** by the sequence of methylation, reduction of ketone to alkane followed by deprotection. The synthesis of challenging indanone **4** was imagined from readily available aldehyde **5** via Knoevenagel condensation, reduction of C=C bond and acid mediated intramolecular cyclization.

As outlined in Scheme 2, the synthesis of **1** started with the *ortho*-formylation of commercially available phenol **6** by treatment with MgCl₂, Et₃N, (HCHO)_n in dry acetonitrile to give the aldehyde **7** in 72% yield [10]. The phenolic group in **7** was protected with MeI, K₂CO₃ in DMF to give the desired aldehyde **5** in 92% yield [11], which was subjected to Knoevenagel condensation with malonic acid to deliver the cinnamic acid **8** in 93% yield [12] (see Scheme 2).

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Article

CXCR6-CXCL16 Axis Promotes Breast Cancer by Inducing Oncogenic Signaling

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Simple Summary: Breast cancer (BrCa) is the second leading cause of cancer-related deaths in American women, and its incidence is on the rise. Insufficient understanding of the mechanisms leading to BrCa limits the effectiveness of the treatment. In this article, we show the importance of a chemokine axis-CXCR6/CXCL16 in supporting BrCa progression. We have delineated BrCa-promoting mechanisms induced by this chemokine axis at the molecular level. This work projects the therapeutic significance of CXCR6/CXCL16 signaling for the treatment of BrCa.



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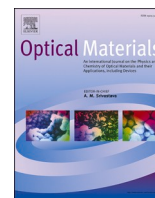
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Abstract: Precise mechanisms underlying breast cancer (BrCa) metastasis are undefined, which becomes a challenge for effective treatments. Chemokine signaling instigates the trafficking of cancer cells in addition to leukocytes. This study aimed to ascertain the clinical and biological significance of the CXCR6/CXCL16 signaling axis in the pathobiology of BrCa. Our data show a higher expression of CXCR6 in BrCa cell lines and tissues. Stage-III BrCa tissues express significantly higher CXCR6 compared to stage-II tissues. The ligand, CXCL16, could remain tethered to the cell surface, and, after proteolytic shedding of the ectodomain, the N-terminal fragment is released, converting it to its oncogenic, soluble form. Like CXCR6, N-terminal CXCL16 and ADAM-10 were significantly higher in stage-III than stage-II, but no significant difference was observed in the C-terminal fragment of CXCL16. Further, stimulation of the CXCR6/CXCL16 axis activated Src, FAK, ERK1/2, and PI3K signaling pathways, as per antibody microarray analysis, which also underlie CXCL16-induced F-actin polymerization. The CXCR6/CXCL16 axis induces cytoskeleton rearrangement facilitating migration and invasion and supports BrCa cell survival by activating the PI3K/Akt pathway. This study highlights the significance of the CXCR6/CXCL16 axis and ADAM10 as potential therapeutic targets for advanced-stage BrCa.

Keywords: breast cancer; chemokine; chemokine receptor; ADAM10

1. Introduction

Breast cancer (BrCa) is the most common malignancy and the second leading cause of cancer-related deaths in American women [1,2]. Current predictions suggest that the worldwide incidence of BrCa and related death is on the rise [3]. Hormone therapy, surgery, chemotherapy, radiation, and targeted therapy are helpful; however, approximately 40,920 are expected to die from the disease [4]. This emphasizes the need to improve



Research Article

Performance optimization of lead free-MASnI₃ based solar cell with 27% efficiency by numerical simulation

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ABSTRACT

The photovoltaic devices based on organic-inorganic halide perovskite materials have witnessed a rapid increase in performance and are marching towards commercialization. Recently, lead-free perovskites have drawn huge attention as one of the major research topics over toxic lead-based materials. Here, we report the optimized device performance of methylammonium tin iodide (MASnI₃) based perovskite solar cell by using numerical simulation. The influence of different key parameters, such as different hole transport layers (HTLs), doping density, thickness of different layers including defect density on the device performances is thoroughly analysed through numerical simulation. The optimized device architecture with copper (I) oxide (Cu₂O) as the hole transport layer and TiO₂ as electron transport layer shows the highest power conversion efficiency of 27.43%, short circuit current density of 25.97 mA/cm², open-circuit voltage of 1.203 V, and fill factor of 87.79%. This indicates that by optimizing the device parameters, it is possible to achieve high performance lead-free perovskite solar cells experimentally in future research.

1. Introduction

Perovskite solar cell (PSC) has emerged as one of the most promising photovoltaic technology with power conversion efficiency (PCE) of more than 25% in a single junction architecture, which can challenge the traditional silicon solar cell and is marching towards commercialization in just a little more than a decade since its inception [1,2]. However, PSC's journey towards industrialization is being hindered by a handful but serious factors such as the device stability in the air under illumination, and toxicity of the materials used [3,4]. So far the most successful composition in perovskite solar cells is the combination of methylammonium (CH₃NH₃⁺) (MA), formamidinium (NH₂CHNH₂⁺) (FA), and cesium (Cs⁺) in A cation site, lead(Pb) in B cation site, and Iodine (I), Bromine (Br) in X anion site in the ABX₃ perovskite structure [5]. However, the presence of toxic & heavy metals like lead associated with the whole lifecycle of perovskite solar cells is the major concern from an environmental perspective [6]. Therefore, besides having high efficiency, still, research communities and industrial people are more sceptical about its future which paves the way to lead-free perovskite

materials. So researchers are trying to explore the lead-free perovskite materials for solar cell application. Many lead-free perovskite absorber materials possess wide band gaps that make them suitable to substitute the toxic lead containing perovskites. Some examples include direct bandgap methylammonium tin iodide (MASnI₃: 1.3 eV), cesium tin iodide (CsSnI₃: 1.22 eV), formamidinium tin iodide (1.41 eV) [7–9]. Tin based perovskite absorber materials are being given more importance in the research sector because of their properties which are similar to that of lead halide perovskites with high PCE. However, the degradation of these devices in the ambient atmosphere is a major challenge that needs to be addressed. Neol et al. have reported lead-free MASnI₃ based PSC which exhibited a PCE of 6% [10]. The device was fabricated through a spin coating process in closed nitrogen filled glove box to avoid exposure to air with a cell configuration of FTO/c-TiO₂/mp-TiO₂/MASnI₃/Spiro-OMeTAD/Au. The Sn²⁺ present in the light harvesting material gets oxidized into Sn⁴⁺ (a more stable state) when exposed to the ambient atmosphere. Thus, this results in destroying the charge neutrality of light absorbing material which leads to the formation of SnO₂ and methyl ammonium iodide (MAI) [10]. When it comes to properties, the results

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Impact Assessment of Mining Activities on Surface and Sub-Surface Water Condition of Ramgarh, Jharkhand, India using Geospatial Techniques

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Abstract

This work illustrates the impact of excessive mining on the precipitation trends and ground water condition of the Ramgarh district over a period of 12 years (2007-2018). The Landsat 8 and Landsat TM- 5 data is processed under Arc-GIS in order to compare the LULC maps. Out of 7 classified classes, the Results obtained indicate the expansion of the mining area, barren land, settlement, and water body by 10.95%, 10.07%, 3.44%, and 0.43%, while a reduction in the forest, fallow, and crop land by 11.24%, 11.31%, and 2.34% respectively. The TRMM 3B43 data is used to trace out the annual precipitation values of 5 selected raster location points through Arc GIS. The annual precipitation under the mining regions (lower Mandu, Ramgarh, Bhurkunda) shows a decreasing trend. The Mann-Kendall test and Sen's slope estimator method is used in order to evaluate the ground water pattern in the pre- and post-monsoonal conditions. The Mandu block, the densest mining region of the district with the positive Z values of 1.714 and 0.137 in the pre- and post- monsoon period shows a decrease in the ground water level at the rates of 0.103 m/year and 0.017 m/year, respectively. The continuous rise in the mining activities has created an alarming shift of weather pattern and deteriorated ground water table in Ramgarh.

1. Introduction

The mining activities disturb the equilibrium of the ecosystem, which causes an adverse effect on the precipitation trends [3]. The high insolation coverage due to heavy deforestation causes a significant thermal rise in the area. This phenomenon further results in the reduction of the moisture content, which ultimately affects the cloud formation process [3, 4]. A huge decrease in the green cover creates an imbalance in the evapotranspiration rate, which directly affects the local precipitation trend [1-3]. The changing hydrological behavior and its frequent alarming trends are one of the major aspects, where a quick and innovative approach is required.

The extensive mining operations make an aggravation in the sub-surface seepage framework. These disturbances incorporate a condition that brings down the ground water table

of the area. The insoluble coal dust released from the mines starts to settle down at the base of the local repositories (lakes, wells, ponds, etc.), which disrupts the percolation capacity, and ultimately reduces the ground water level of the area [3, 4]. A deep excavation generally disturbs the natural subsurface arrangements, which changes the relocation of groundwater streams [4].

The organic aerosols released from the coal mines have been found to have a significant impact on the cloud formation and the condensation processes [7]. The study based on the interactions between the cloud formation and the aerosol emission in the warm season of central east China has concluded that the aerosols (black carbons) are responsible for the enhancement of atmospheric stability, which further results in the depression of upward motion of evaporation and



Investigating capability of open archive multispectral and SAR datasets for Wheat crop monitoring and acreage estimation studies

Manjari Upreti^{1,2} · Deepak Kumar¹

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Abstract

There is a necessity for new methods and technology for several agricultural applications and decision support systems. Technological development at the global, national, and regional level has shown a path for the application of spaceborne remote sensing for agriculture purposes. Remote sensing technology eases to detect areas within the plots for a reliable data supply to analyze the data. Spaceborne synthetic aperture radar (SAR) data are capable to provide a reliable data supply throughout the year. The global repetition rate is up to 12 days. The datasets acquired from the Sentinel-1 platform facilitates a ground resolution of 20×20 m and these sufficient for the synchronization of spaceborne multispectral and radar datasets for enhanced agricultural cropland monitoring applications and decision support systems. Sentinel-1 data is a C-band radar data sets in dual-polarizations. The signal intensity changes over according to humidity in the soil or vegetation cover and the surface structure. The variations in signal information being recovered at the sensor end help in the informed decision making. Besides, SAR datasets are capable to provide information on the phenological stage of agricultural cropland along with crop-type differentiation for specific use cases. The synchronous utilization of spaceborne multispectral and radar datasets for enhanced agricultural cropland monitoring applications and decision support systems can be transformed into informative map products for several processes. The same technology can be beneficial for monitoring crop conditions during any disaster and early warning systems for proper management of available resources.

Keywords Agriculture · Data fusion · Estimation · Monitoring · Multi-spectral · SAR

Introduction

During the last 40 years, the monitoring of agriculture crops with the help of a space-borne satellite system has moved from a research subject to an operational exercise. Most frequently, the normalized difference vegetation index (NDVI) is used as a proxy signature to showcase the presence or absence of vegetation health for determining variable growth rate or decline of vegetation cover (Chen et al. 2006; García-León et al. 2019; X. X. Zhang et al. 2010). We have shifted our attention

towards agricultural crop monitoring, assessment, and yield estimation (Guzinski and Nieto 2019; Park et al. 2016; Potopová et al. 2020). It is a well-known fact that all traditional electro-optical satellite system applications are having certain limitations for frequent or continuous agricultural monitoring due to their incapability to look through the clouds. In this regard, there is ample space for synchronous use of multi-spectral and radar satellite datasets with global coverage and high spatial resolution to augment the current operations (Bassuk et al. 2015; Mermoz et al. 2015; Shastri et al. 2015). There has been long series of use of satellite imagery for monitoring agriculture all around the globe. Almost all agronomic service provider including agrochemical companies are marching towards the use of satellite images. They are typically translating the available information content to a vegetation index to derive the information on the state of the vegetation health for their business intelligence or passing this information's to agronomists and farmers for improvement in the agriculture processes (Barbosa et al. 2006; Blaschke et al. 2019; F. Zhang et al. 2019). This

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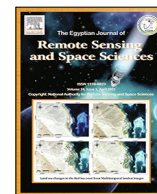
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Spectral aspects for monitoring forest health in extreme season using multispectral imagery

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ABSTRACT

Forest health monitoring is needed for forest management in respect to eradication of diseases and insects. Spectral indicators help to retrieve forest health at different scales. Although, indicators of forest condition from remote sensing require narrow spectral bands but these bands are not available in multispectral imagery. Therefore, a systematic approach to evaluate forest health using Sentinel 2A imagery is developed. Anthocyanin Reflectance Index (ARI1), Structure Insensitive Pigment Index (SIPI) and Normalized difference vegetation index (NDVI) were combined for forest health analysis using ENVI forest health tool model. Canopy Chlorophyll Content (CCC) was retrieved using the SNAP software approach. The overall accuracy in forest health mapping was 0.82 and 0.86 in the month of May and October respectively, validated through in-situ analysis. The excellent forest health exhibit increased by 6 % in October (after the rainy season) compared to May (summer season). The substantial proportion of forest in the area is mature which showed low changes compared to young forest. The reduced regression was found during May ($R^2 = 0.249$) between chlorophyll content and forest health due to decrease in leaf photosynthetic pigments whereas better relationships were noticed in October ($R^2 = 0.58$). The 38% differences in the chlorophyll content in the two seasons indicated that CCC is sensitive to stress pigments in forest.

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1. Introduction

Forests are in disorder due to global climate change, diseases and air pollution, which made the governing aspect of forest health a high priority issue (Witzell and Martin, 2018). Forest Health Monitoring (FHM) is a necessary step to ensure sustainable development and requires the gathering of information for forest conditions concerning the status of insect inhibiting plants, leaf defoliation and trunk damage. The FHM should signify the type of environment stressor, easily measured indicators, the complexity and sensitivity of environmental receptors (Foster et al., 2019). There are multiple approaches developed for forest health monitoring

which includes forest inventory plotting and experimental analysis (Traub et al., 2017). These traditional survey techniques were limited by small spatial coverage confined to plotting area and sample locations (Dash et al., 2017). Modern remote sensing techniques have potential to resolve this problem but there is still inconsistency between the information retrieval by researchers and forest managers for understanding type of stressors, forest disturbances, health issues and their effects (Lausch et al., 2018).

Forest health monitoring has a long practice often associated with monitoring programs at national, international, and regional level, in which graded ecological indicators of forest health have been used and created. In Germany, FHM initiative consists of three level of analysis: the first level consists of systematic sample grid of permanent plots, the second level consist of continual sampling in selected forest ecosystems and the third level comprises National Forest Inventory (NFI) at every 10 years and 45 countries integrated into it (JHTI, 2018; Lorenz, 1995). In the USA, USDA forest service performed FHM to determine the changes, status, and trends in indicators of forest health on an annual basis. In Europe and North America, the tree canopy condition, e.g., defoliation and dieback, is mostly used as a pointer for forest wellbeing assess-

Abbreviations: CCC, Canopy Chlorophyll Content; ARI1, Anthocyanin Reflectance Index; NDVI, Normalized difference vegetation index; SIPI, Structure Insensitive Pigment Index; FHM, Forest Health Monitoring; S2, Sentinel 2A; FHI, Forest Health Index.

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**SPACE OF INVARIANT BILINEAR FORMS UNDER A
REPRESENTATION OF $SL_2(3)$**

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Abstract: Let n be a positive integer. In this paper we compute the space of invariant bilinear forms under an n degree representation of the special linear group $SL_2(3)$ and its dimension over the complex field \mathbb{C} . We discuss the existence of a non-degenerate invariant bilinear form explicitly.

Keywords and Phrases: Bilinear forms, Representation theory, Vector space, Direct sums.

2020 Mathematics Subject Classification: 20C33, 15A63, 15A03.

1. Introduction

Representation theory enables the study of a group as operators on certain vector spaces. Since last several years the search of non-degenerate invariant bilinear forms has remained of great importance among researcher. Such types of studies acquire an important place in quantum mechanics and other branches of physical sciences.

Let G be a finite group and \mathbb{V} , a vector space over a field \mathbb{F} , then we have following.



Zone-Wise Optimal Operation Policy and Evaluation of System Performance Measures

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Abstract A zone-wise (conservation and flood control zone) operating policy has been developed for the Maithon multipurpose reservoir, situated on Barakar River, a major tributary of Damodar River, of Jharkhand and West Bengal, India. Conservation zone policy has been designed for the purpose of adequate water supply to different sectors while flood control zone policy for real-time flood protection. Hedging rule is applied through Monte Carlo simulation (MCS) in which twelve number of discrete rationing factor (random variable for 5000 iteration) has been considered for respective month to hedge the water to derive an operating policy for conservation zone whereas statistical approach is used to derive the operating policy for flood control zone to mitigate the flood. Under the flood control, a policy has been derived to release flood at different levels of flood control zone to mitigate flood. Further three storage performance indicators reliability (ratio of the number of times the target demand was satisfied to the total number of times the reservoir was operated), resilience (ratio of the number of times the system moved from failure to success, to the total number of periods the system was in failure state) and vulnerability (maximum period deficit) has been investigated to check the system performance measures of Maithon reservoir.

Keywords Hedging rule · Monte Carlo simulation · Reservoir operating policy · Statistical method · Performance indicators

Abbreviations

MCM	Million cubic meter
MCS	Monte Carlo simulation
β	Reservoir constant
α	Flood reduction ratio
V_{\max}	Maximum vulnerability
V_{mean}	Mean vulnerability
Ra	Annual reliability
Fy	Number of failure years
Ty	Total time duration in years
Rv	Volume reliability
Vs	Volume of water supplied
Vd	Water demanded
R_t	Time reliability
fp	Failure periods
Tp	Total periods
Ot	Outflow at time t
It	Inflow at time t
S_{t+1}	Storage of reservoir for next period
S_t	Available storage after water release
R_t	Water released
S_{\max}	Maximum storage
A_w	Available water for release
Hw	Hedged water
Ast	Available storage for current time period
Hf	Hedging factor
Et	Evaporation loss during time t
It	Inflow during period t
ASt	Available storage
X_t	Event at time t

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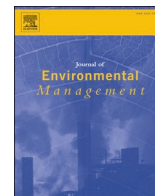
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Energy optimization from a binary mixture of non-edible oilseeds pyrolysis: Kinetic triplets analysis using Thermogravimetric Analyser and prediction modeling by Artificial Neural Network

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ABSTRACT

Pyrolysis kinetics and thermodynamic parameters of two non-edible seeds, *Pongamia pinnata* (PP) and *Sapindus emarginatus* (SE), and their blend in the ratio of 1:1 (PS) were studied using the thermogravimetric analyzer. Kinetic triplets were determined using both model-free [Starink (STR), Friedman (FRM), Iterative Kissinger-Akahira-Sunose (IT-KAS), Iterative Ozawa-Flynn-Wall (IT-OFW), Vyazovkin (VYZ), and Master plot (MP)] and model fitting Coats-Redfern (CR) methods at three different heating rates 10, 30 and 50 °C/min. Activation energies were 192.66, 179.44, and 163.25 kJ/mol for PP, SE, and PS, respectively. It was found that the blend of the two-biomass (PS) showed promising results with lower activation energy compared to the individual biomass. Thermodynamic parameters (ΔG , ΔS , and ΔH) were obtained using the model-free isoconversional method. The three hidden layers of complex neuron topology are well fitted to the experimental DTG curves by artificial neural network (ANN). The study confirmed that the heating rate had a significant impact on the kinetics and thermodynamic parameters. The reaction mechanism was also in consonance with the experimental data. The study suggests that the PP and SE seeds can be an appropriate feed for pyrolysis, and their blend (PS) can be a viable alternative in optimizing the entire process.

1. Introduction

Energy is inevitable for human existence. Everything from industrialization, urbanization, transportation, agriculture to basic day-to-day functioning requires energy. The growth of the global population and enhancement of living standards are further driving energy consumption. The global average per capita energy consumption has increased by over 45% since 1970 (Ritchie, Hannah; Roser, 2020). Majority of this consumption is fulfilled through fossil fuels, be it oil (33.1%); coal (27.0%) or gas (24.2%) followed by hydro (6.0%), renewable (5.0%) and nuclear (4.3%) fuels (BP, 2020). At present, the world meets over 80% of its annual energy requirement through fossil fuels. Such high dependence on fossil sources implies higher Green House Gas (GHG) emissions, a severe impact on climate change, and more uncertainty due to the depleting reserves. Given these challenges, the need to explore

new energy sources is on the rise, and diversifying the energy basket, with a special focus on renewable sources, is intense. Biofuel is one such renewable fuel on which the globe is looking to meet its future needs sustainably. Biofuels provided 93% of all renewable energy. Global biofuel production has risen consistently over the past years and is forecasted to grow 25% by 2024 (International Energy Agency (IEA), 2019).

Biofuels are extracted from biomass such as woody biomass, farm residue, edible and non-edible seeds, spoiled and waste food material, etc. Depending on the type of feed used, biofuels are categorized into the first, second, and third generations. First-gen fuels are generated using edible materials such as sugar, starch, vegetable oil, etc. The non-edible materials such as lignocellulosic feeds, spoiled and leftover foods, agriculture wastes, etc., give second-gen biofuels. Fuels obtained from algal biomass constitute the third-gen category (Lee and Lavoie, 2013). The use of edible resources as feed-in biofuel generation always poses a

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Evaluating Water Supply Risk In The Middle Reaches Of Subarnarekha River Basin By Using WEAP Model

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The allocation of limited water resources poses a challenge when demand from different stakeholders are gradually increasing. Demand supply analysis for different scenarios can help the planners for better allocation of these precious natural resources. In the present study, the Water Evaluation and Planning System (WEAP) model was applied to analyse water demand and supply potential in the middle reach of the Subarnarekha river basin, Jharkhand. Demand sites used were classified as an industrial area, institutional water demands area, agricultural land and human and livestock settlement. Annual water use rate per person, per hectare and per head of livestock were determined and used as input alongwith other hydrological input parameters to the WEAP model. For WEAP modelling framework, the year 2010 was chosen as a current year. It has observed dry conditions with an annual rainfall of nearly 624.8 mm whereas, the years 2011 and 2013 experienced high rainfall (1836.4 and 1779.8 mm) resulting in wet conditions. The maximum flow to the groundwater storage was found in the monsoon months compared to the non-monsoon months as an obvious phenomenon. It was noticed that the year 2010 showed the lowest surface runoff because the year 2010 observed the minimum rainfall and the years 2011 and 2013 showed the highest surface runoff. It can be seen that rainwater is available to meet the crop water demand in monsoon months. The agriculture demand

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 Nivesh, S. , Patil, J.P. , Goyal, V.C. (2023) *Environmental Science and Pollution Research*

Sustainable Water Supply and Demand Management in Semi-arid Regions: Optimizing Water Resources Allocation Based on RCPs Scenarios

 Mirdashtvan, M. , Najafinejad, A. , Malekian, A. (2021) *Water Resources Management*
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An environmental approach for the photodegradation of toxic pollutants from wastewater using silver nanoparticles decorated titania-reduced graphene oxide

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ABSTRACT

Light-induced demineralization of organic pollutants is a recent development in the field of waste treatment. The present study focuses on TiO₂-rGO-Ag hybrid nanocomposite through a two-step simultaneous synthesis pathway. The methods primarily involving facile solvothermal treatment (TiO₂-rGO nanocomposite) in a water-ethanol mixture, followed by microwave irradiation method for deposition of silver (Ag) nanoparticles over the Binary nanocomposite synthesized. The resulting hybrid photocatalyst was well, and in-detail characterized using analytical techniques such as High-Resolution X-ray Diffractometer (HR-XRD), Transmission Electron Microscopy and High-Resolution Transmission Electron Microscopy (TEM/HR-TEM), High-Resolution Scanning Electron Microscopy (HR-SEM), Fourier-Transform Infra-Red Spectroscopy (FT-IR), Energy Dispersive X-Ray Spectroscopy (EDX), Raman Spectroscopy, Solid-State UV-Vis Spectroscopy and X-Ray Photoelectron spectroscopy (XPS). The nanomaterial was examined to determine photocatalytic property by conducting a photo-degradation experiment of an aqueous solution of Methylene Blue (MB) dye and monitoring the changes. The photocatalytic efficiency of the nano-hybrid synthesized was also analyzed in detail for the degradation of compounds that active components of petrochemical pollutants such as Benzene, Toluene, and Phenol the Visible region of radiation in a photochemical reactor under ambient reaction conditions. The set of experiments suggested that the photocatalytic efficiency of ternary nanocomposite synthesized was quite noticeable. The variation in the catalyst's photoactivity with the change in the functional group was monitored, and the rate of reaction has been correlated with attached substituents.

1. Introduction

Heterogeneous catalysis (a catalysis process where catalysts and reactants are in different phases) has undoubtedly emerged as a

breakthrough in the field of environmental protection. Photocatalysis, one such kind of heterogeneous catalysis method, occurs between solid, i.e., catalyst (nanocomposite as for the system we investigated) primarily made up of semiconductor containing TiO₂ and gas or liquid

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Understanding planform dynamics of the Ganga River in eastern part of India

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Abstract To understand the natural processes of planform change, meandering and formation of braid bars, satellite sensor data of few decades play a significant role. The present research focuses on the planform dynamics of Ganga River from Sahibganj (Jharkhand) to Jalangi in West Bengal, India. This study is based on the sequential river planform maps. These maps were prepared using Landsat 1, Landsat 3, Landsat 4, Landsat 5 and Landsat 7 data for the period 1975–2015 at an interval of 5 years. The sinuosity index, braiding index and spatial analysis of maps were used to assess and classify the river into straight, braided and meander categories. This was observed that braiding index is continuously increasing and the meandering index has decreased from 1.6 to 1.24 during 1975 to 2015. The results showed the changes in channel migration with time and space. From the analysis, it is observed that the factors causing shifting of the Ganga River in some areas are natural and anthropogenic. Landsat images were found to be effective in determining the meandering index, braiding index and planform change of a river.

Keywords Meandering index · Sinuosity index · Braiding index · Farakka barrage · Sahibganj · Ganga River

1 Introduction

A River is a dynamic and crucial part of the physical environment. Study of the behaviour of a river gives prime importance to wide variety concerns, like flood control, navigation and water resource development to recreation. Meandering is very common to most of the rivers in the world nowadays, which is occurring due to various natural and human activities [1]. Excess of turbulence, slope of the river, streamflow, bed and side resistance capacity are the natural causes of most of the meandering rivers. Human activities also influence the river meandering by constructing a dam, settlement and adopting faulty agricultural practices [2]. Meandering property of a river has attracted many engineers and researchers over the last few decades. In alluvial planes, a meander of rivers consists of a number of consecutive curves connected with short straight stretches crossing. In a plan view, the appearance of a reach describes the pattern of a river. Based on a plan view of a major river, the pattern of a river reach is broadly categorized into three patterns such as straight, braided and meandering [3]. A straight river follows almost a straight-line course. A meandering channel follows a sinuous course of Y-shaped or U-shaped, consists of alternating bends. Generally, braided rivers are formed due to poorly defined unstable banks. Ganga River basin covers about 26% of India's total landmass. This river basin supports livelihoods of millions of people of India. The basin extends through the countries like India, Bangladesh, and Nepal with a catchment area of about 1,086,000 km². On the north side of the basin, there is Himalayas and on the west side there is Aravalli. South side of the basin is surrounded by Vindhyas and Chhotanagpur plateau and east side Brahmaputra Ridges [4]. In India, the Ganga River has

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Review

Wonder or evil?: Multifaceted health hazards and health benefits of *Cannabis sativa* and its phytochemicals

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ABSTRACT

Cannabis sativa, widely known as ‘Marijuana’ poses a dilemma for being a blend of both good and bad medicinal effects. The historical use of *Cannabis* for both medicinal and recreational purposes suggests it to be a friendly plant. However, whether the misuse of *Cannabis* and the cannabinoids derived from it can hamper normal body physiology is a focus of ongoing research. On the one hand, there is enough evidence to suggest that misuse of marijuana can cause deleterious effects on various organs like the lungs, immune system, cardiovascular system, etc. and also influence fertility and cause teratogenic effects. However, on the other hand, marijuana has been found to offer a magical cure for anorexia, chronic pain, muscle spasticity, nausea, and disturbed sleep. Indeed, most recently, the United Nations has given its verdict in favour of *Cannabis* declaring it as a non-dangerous narcotic. This review provides insights into the various health effects of *Cannabis* and its specialized metabolites and indicates how wise steps can be taken to promote good use and prevent misuse of the metabolites derived from this plant.

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Amit Kumar Prasad · Jitendra Kumar · Ashok Kumar

Isotropic uncharged model with compactness and stable configurations

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Abstract In this study we have obtained a new exact model for relativistic stellar object by solving Einstein's field equation with help of Buchdahl metric. The model is capable to represent some known compact stars like Her X-1, 4U 1538-52 and SAX J1808.4-3658. The model satisfies the regularity, causality, stability and energy conditions. Using the Tolman–Oppenheimer–Volkoff equations, we explore the hydrostatic equilibrium for an uncharged case. We have also compared these conditions with graphical representations that provide strong evidences for more realistic and viable models.

Mathematics Subject Classification 83C05 · 83C15 · 83C75

1 Introduction

An analysis of the solution of Einstein field equation shows that the exact solution plays an important role in the development of many areas of the gravitational field such as black hole solution, solar system test, gravitational collapse and so on. Generally in astrophysics compact stars are considered to fall in three categories, white dwarfs, neutron stars and black holes which are formed due to gradual gravitational collapses. This classification is based on the internal structure and composition of stars, where the former contains matter which is one of the densest forms found in the universe. According to the strange matter hypothesis, strange quark matter could be more stable than nuclear matter and thus neutrons star should largely be composed of pure quark matter. Possible observational signatures associated with theoretically proposed states of matter inside the compact stars have remained an active research area in astrophysics and different types of mathematical modeling of such compact objects being considered. The singularity-free interior solutions of the compact object have important consequences in relativistic astrophysics. The study of high-density objects like neutron stars, quark stars, and white dwarfs, form their microscopic composition and properties of dense matter is one of the most fundamental problems in modern astrophysics.

In general, it is important to measure the mass and radius [1, 2] of compact stars which depends on the equation of state [3–6]. The motivation to undertake such a task because the interior structure of compact stars can vary with masses. On the other hand, Buchdahl [7] proposed a method on the mass-radius ratio of

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Development of dye-sensitized solar cell using *M. philippensis* (kamala tree) fruit extract: A combined experimental and theoretical study

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Summary

In this work, we have extracted natural dye from the pericarp of *Mallotus philippensis* (kamala tree) fruit which is commonly found in East Asia. The natural dye extract has been used such a photosensitizer for dye-sensitized solar cells. Density Functional calculations on one of the major constituent natural dye rottlerin, have been performed to check the properties and applicability of the proposed dye as a photosensitizer and manifested high electron injection efficiency. The best performing device exhibited a power conversion efficiency of 0.55% under 100 mW/cm². This kind of non-toxic and biodegradable natural dye can easily be extracted from an inedible source using a very low-cost technique and therefore it can provide the best alternative to the synthetic dye for solar cells.

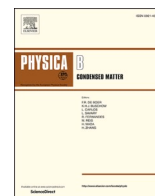
KEYWORDS

density functional theory, dye-sensitized solar cell, natural dye, photosensitizer, Rottlerin

1 | INTRODUCTION

Rocketing demand for energy has emerged as a serious bone of contention as studies have figured the threat of defined exhaustibility and negative environmental impact of fossil fuels. Among all renewable energy resources, solar energy is quiet, inexhaustible, easily exploitable, and adjustable to enormous applications. With various positively configured prospects like high efficiency, low production cost, easy fabrication techniques of Dye-sensitized solar cells (DSSCs) stand as an option which could provide key to the problem since it was first reported by Regan and Grätzel in 1991.¹ A classic DSSC consists of TiO₂ nanoparticles coated photoanode, light

absorbing dye molecules which generate photoelectrons, an electrolyte containing a redox couple for electron transfer, and a counter electrode.²⁻⁵ In DSSCs, photosensitizer or dye molecules play a very important function in the overall operation. Therefore, a significant effort has been spent on designing dye molecules for better absorption of the solar spectrum which leads to higher output performances.⁶⁻⁸ Extensive research in DSSC using Ruthenium based complex as photosensitizer has been studied with so far highest efficiency of 11.9% has been achieved.⁹ Besides that, organic dye molecules with D- π -A structure also designed as an alternative to the ruthenium complex. Lately, Yao et al demonstrated PCE of 13% utilizing dithienopicenocarbazole organic dye



Optimization of magnetic properties and hyperthermia study on soft magnetic nickel ferrite fiber

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ABSTRACT

Nickel ferrite fiber (NFO-F) was synthesized using the electrospinning technique and annealed at five different temperatures (500, 600, 700, 800, and 900 °C) to study its effect on crystal structure and magnetic properties. The X-Ray diffraction pattern analysis was carried out to explore its crystal structure. The morphology and microstructure of fibers were studied by employing the Field Emission Scanning Electron Microscopy technique. The crystallinity of the material increases with the increase of annealing temperature from 500 to 900 °C. The saturation magnetization of nickel ferrite fiber increases from 31.1 to 54.0 emu/g with the increase in annealing temperature. The anisotropy constant for NFO-F calculated using the Law of Approach to Saturation (LA) and it shows the highest value for 900 °C annealed sample. Hence, the hyperthermia property of NFO-NF annealed at 900 °C has been explored. The Specific Absorption Rate (SAR) of NFO-NF calculated using Linear Response Theory and the Box-Lucas models.

1. Introduction

Spinel ferrite nanomaterials have been extensively studied due to their distinguished magnetic and electrical properties [1]. These materials exhibit remarkable properties such as high saturation magnetization, high magnetic anisotropy, low eddy current loss, and good chemical stability. Hence, these are promising materials for technological and biomedical applications [2]. The chemical formula of spinel ferrite is AB_2O_4 , where A is a tetrahedral sub-lattice and B is an octahedral sub-lattice. Here, Ni^{2+} , Fe^{2+} , Cu^{2+} , Mn^{2+} , Co^{2+} , Zn^{2+} , Mg^{2+} and Fe^{3+} are metal cations which can occupy A, B sub-lattices for normal/inverse spinel crystal structure formation. Among them, the nickel ferrite is soft in magnetic nature and possesses high saturation magnetization [3].

The magnetic and structural properties of magnetic material depend on its microstructure, and synthesis method, which could be utilized for various applications. The different synthesis routes could be employed to prepare magnetic nanomaterials such as co-precipitation method, sol-gel method, solid-state reaction method, hydrothermal method, electrospinning, and electrodeposition-method. The sol-gel method is a low-

cost method that maintains stoichiometric ratio and phase purity in the oxide material [4,5]. In the electrospinning method, metal nitrate/metal acetate solution is mixed with polymer solution for nanofiber fabrication. It is an easy, cost-effective, and most straightforward technique to synthesize nanofiber. Dan Li et al. reported the synthesis of nickel ferrite nanofiber by electrospinning method and studied the crystal structure and magnetic properties. They reported the comparative magnetic study of nickel ferrite nanoparticles and nanofiber at low temperature (10 K) & room temperature (300 K). It was found that nanofiber showed an enhanced coercivity at low temperatures compared to nanoparticles [6]. Juan-Wang et al. reported the nickel ferrite nanofiber from the multi-particle chain to the single-particle chain with the effect of annealing temperature [7]. Jin Zhang et al. reported the synthesis of nickel ferrite nanofiber using iron acetate as an iron precursor [8]. H. Albertran et al. reported the Erbium substituted nickel ferrite nanofiber and its characterization and magnetic properties. The magnetic properties show maximum values for Er = 0.02 substitution [9]. G. Sreenivasulu et al. reported the magnetic field-assisted self-assembly of core-shell nanofiber of nickel ferrite and lead zirconium titanate [10]. Orapan Saensuk et al. studied the nickel ferrite nanofiber by annealing at 500, 600, 700,

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Nanotechnology-based strategies for the management of COVID-19: Recent developments and challenges

Singh, Ritu^a ; Behera, Monalisha^a; Kumari, Nisha^a; Kumar, Sanjeev^b; Rajput, Vishnu D.^c; Minkina, Tatiana M.^c; Adnan, Mohd^d; Siddiqui, Arif J.^d; Kumar, Narendra^e

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Stellar model for anisotropic compact stars in Schwarzschild's coordinates

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In this article, we have presented a completely new, well-behaved, physically acceptable and stable anisotropic fluid sphere model. For this purpose we have used a well-known Vaidya-Tikekar [*J. Astrophys. Astron.* **3**, 325 (1982)] ansatz for metric potential g_{rr} to generate the model. We have investigated the various physical aspects for our model such as energy density, pressure (radial as well as transverse), anisotropy factor, mass, compactness parameter, surface, and gravitational redshifts. Energy conditions, equilibrium, and stability analysis has been done using graphs. This ensured that our proposed solutions are well-behaved and hence represent physically acceptable models for anisotropic fluid spheres. For comparison with observational data we have considered the compact stars: Her X-1, 4U1538-52, SAX J1808.4-3658, LMC X-4, SMC X-1, EXO 1785-248, Cen X-3, 4U 1820-30, PSR J1903 + 327, 4U 1608-52, Vela X-1, PSR J1614-2230, Cyg X-2 and PSR B1913 + 16. The calculated value of central density of each of these compact stars, using this model, is of order 10^{14} or 10^{15} , which is considerably high and consistent with ultracompact stars. We have also estimated the approximate moment of inertia for each of the considered compact stars.

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I. INTRODUCTION

Astronomical objects having an extremely high density are known as compact objects. These objects represent the final stage of evolution of a star. The recent developments in cosmology have helped to analyze numerous interesting facts regarding the evolution of these compact objects. Though the study of emission spectra and rotational frequencies of stellar objects make us able to explain many of their features, it is still a great challenge to measure some of the important parameters like mass, radii, internal composition, etc., which cannot be inferred directly from observational data. In this scenario the theory of general relativity comes into the picture.

Theoretical relativistic stellar models are used to predict many crucial properties of compact objects which were impossible to determine otherwise. In order to produce physically viable models of compact stars, a considerable amount of effort has been applied in gaining understanding of the properties of anisotropic matter. Extreme internal density (above nuclear matter density) and strong gravity of compact objects hints that pressure within these objects may not be in the form of a perfect fluid. Theoretical study indicates that pressure within such stars are mostly anisotropic. This means, the pressure inside the fluid sphere can specifically be decomposed into two nonidentical parts: the radial pressure, p_r and the transverse pressure, p_t , which

acts in a mutually perpendicular direction. A scalar field with nonzero spatial gradient is an example of a physical system with anisotropic pressure. Self-bound systems composed of scalar fields, the “boson stars” and the energy-momentum tensor of both electromagnetic and fermionic fields are naturally anisotropic [1,2]. Wormholes and gravastars are also considered as anisotropic.

Anisotropy is sufficient for the study of compact stars with dense nuclear matter [3,4]. In the absence of an electric field, the presence of nonzero anisotropy is an important component in modeling relativistic stellar systems. In a stellar distribution anisotropy may occur for different reasons. After the work of Bowers and Liang [5] on the anisotropic relativistic compact star, many researchers have investigated the possible origin of anisotropy in compact stars. Ruderman [6] suggested that the nuclear matters at very high density of order 10^{15} g/cm³ (at the core), starts interacting relativistically that arises anisotropy in pressure. It is argued by Kippenhahn and Weigert [7] that anisotropy in pressure may also arise due to the formation of superfluid neutrons inside stars. There is a number of research work present in literature to validate the fact that pressure anisotropy can be triggered by presence of solid core, various types of phase transition [8], pion-condensation [9], slow rotation [10], strong magnetic field [11], mixture of two fluids [12,13] etc. Viscosity may additionally be a source of local anisotropy. Some numerical calculations on the effects of viscosity induced anisotropy are presented by Barreto *et al.* [14,15]. A comprehensive list of physical phenomena producing pressure anisotropy

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Aquatic weed as a biorefinery resource for biofuels and value-added products: Challenges and recent advancements

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ABSTRACT

Aquatic weeds have posed a challenge in their containment to halt its spread worldwide. When removed from the water systems, huge capital and human resources are diverted for its safe management and disposal. When used as a potential resource, the aquatic weeds can be profitable and beneficial. The contents of carbohydrate, protein and lipids make aquatic weed a potential feedstock in production of biofuels. Lignin and sugar component of aquatic weed could be utilized in production of bio-oil, combustible gases and heat energy using thermochemical methods. The sugar portion could be subjected to fermentation to produce bio-ethanol, bio-methanol and bio-butanol. The lipid fraction of the aquatic weed could be utilized to produce biodiesel. Bio-methane and bio-hydrogen could also be developed from the biomass of aquatic weed by biological processes. A large-scale production of aquatic weed will be feasible with innovative and cost-effective methods for harvesting, drying, transportation of the aquatic weed to processing sites and conversion to respective biofuels. Process intensification (viz. Microwave and sonication) during pretreatment steps could fasten the decomposition of biomass of aquatic weed. A biorefinery approach where the aquatic biomass could yield biofuel, fertilizer, industrially useful chemicals and remediate the wastewater is ought to make the overall process economical, sustainable and environment friendly. The value-added products (enzymes and polymers) derived from the biomass of the aquatic weeds could strengthen the commerciality of the process. Aquatic macrophytes could further be used in food source for animals, fish, and humans; in paper making and in medicinal applications.

1. Introduction

Bioenergy is a sustainable solution to reduce dependence on fossil-based fuels. Rising energy demand and problems associated with conventional feedstocks has driven the quest for novel feedstocks for bioenergy generation. Great amount of interest has been shown by researchers, policy makers and energy industry in identifying and developing novel feedstocks in recent past. A considerable amount of research is currently being conducted in this area mainly focused on identifying suitable feedstocks, developing efficient conversion techniques and reducing the overall production cost. Much emphasis is given on lignocellulosic waste, municipal waste, microalgae, fungi and other biomass in recent past as biofuel feedstocks (Vasić et al., 2021). These feedstocks has shown promising potential for biofuels production (Raslavičius et al., 2018). Energy is commodity product and therefore huge amount of feedstock is required. Aquatic weeds are unwanted growth and present in such a great quantity that lot of efforts goes in

managing these weeds. These unutilized weeds can be directed towards production of bioenergy and other value added products. This abundant potential feedstock is scarcely studied for its biofuel production potential and needs attention from researchers and policy makers.

Aquatic weeds are unwanted plants which grow in water bodies and cause problems to aquatic fauna and water quality (Ganguly et al., 2012). However, recent studies have shown its potential as phytoremediator, feedstock for biofuels and as a resource to develop fertilizer. Managing aquatic weeds through its potential application gained wide attention throughout the world mainly due to their alarming reproductive capacity, which can result in serious ecological damage to water sources (Feng et al., 2017). The damage caused due to aquatic weeds can be prevented by using them as raw material not only for the fuel but also for the production of chemicals and materials, i.e. the development of aquatic weed based biorefineries (Farrell et al., 2006). Aquatic weed biomass as biofuel feedstock provides many advantages over terrestrial energy crops. Aquatic weed biomass does not necessarily require scarce

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COVID-19 and waste management in Indian scenario: challenges and possible solutions

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Abstract

The outbreak of COVID-19 pandemic has created havoc all across the globe causing exponential casualties and tremendous health and economic loss. With increasing COVID-19 cases, the amount of biomedical waste has increased manifolds making more people vulnerable to the pandemic. The developing and underdeveloped countries are already facing the challenges of waste management, and the waste generated during the pandemic scenario has added to the already existing challenges. The improper waste management practices need to be corrected; otherwise, the world will be facing a new disaster that could be termed as ‘waste disaster’. The increase in COVID-19-associated waste (CAW) quantity and their availability in the environment will result in their easy approach to other organisms, which will possibly increase the potential risk of food chain contamination. Some of the countries have already started to make backup plans and are struggling to overcome the ‘waste disaster’. In light of the limited knowledge available on the mutational properties and possible hosts of this newly emerged COVID-19, there is a great demand to have an efficient strategy to prevent the environment from further contamination in India. The necessity of the prevailing time is to create a more efficient, automatic, mechanized, and well-modified waste management system for handling the present situation and delaying the projected waste disaster in the near future in the era of COVID-19. The article aims to address the issues that originated from waste discharges, their potential sources along with possible sustainable solutions.

Keywords COVID-19 · Biomedical waste · Sustainable solutions · Environment

Highlights

- COVID-19 transmission is reduced by use of PPEs Kits, disinfectants and social distancing.
- COVID-19 has led to various socio-economic and environmental challenges.
- Preventive measures taken to mitigate COVID-19 otherwise may lead to a ‘waste disaster’ on the planet.
- A safe & sound waste management techniques for liquid, solid & biomedical waste have been suggested.
- A holistic approach is needed to control the outbreak of COVID-19.
- COVID stimulus package can majorly prompt to control the adverse impact of COVID-19.

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Catchment-level agricultural drought hazard vulnerability analysis of Ganga Basin (India) using spectral indices

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Abstract

The Gangetic Plains (GP) comprising India's food belt and extending over an area of eight lakh square kilometres (8, 35,475 km²) witness recurrent drought which affects food production owing to climate change sensitivity of the region. Agricultural drought vulnerability analysis has been attempted in the present study over the past 19 years to understand the trend of drought and distribution across the specified spatiotemporal spectrum, based on satellite-based drought indices computation viz. Vegetation Condition Index (VCI), Temperature Condition Index (TCI), and Vegetation Health Index (VHI) with the help of Moderate Resolution Imaging Spectroradiometer (MODIS), Normalized Difference Vegetation Index (NDVI) and land surface temperature (LST) data. The results revealed that the basins with high vulnerability are concentrated in the south-western GP exhibiting low values of VHI in contrast to dominantly higher values in the rest of the GP making it very much vulnerable. 15.62% of GP faced extreme to severe drought vulnerability followed by 16.65% moderate vulnerability. Precipitation data from Tropical Rainfall Measuring Mission (TRMM) used for future prediction using Sen's slope method revealed an increasing trend in western GP up to + 40 mm/year while a decreasing trend in the eastern GP up to - 40 mm in yearly accumulated rainfall. The future prediction of temperature showed similar trend as precipitation with a magnitude of 0 to 0.05 °C increase yearly. With the probability of rainfall increasing in the near future, certain water-harvesting structure construction in the western region can ensure good water supply to the crops grown here making them less vulnerable.

Keywords Agricultural drought · Gangetic plain · Geoinformatics · Hazard · Remote sensing

Introduction

Drought is a natural disaster with a gradual onset, an insidious and creeping event that happens in nearly all climatic regimes. Drought is also related to the timing and the efficacy of the rain; thus, each drought year is distinctive in its climatic attribute and impacts (Wan et al. 2004). Precipitation, temperature, and humidity are the core criteria that affect drought. Areas that receive low precipitation and less humid are more prone to drought compared with places that receive a high amount of precipitation and humidity. Moisture stress is

caused by a lack of rainfall, while thermal stress is caused by abnormally elevated air and surface temperatures (Pandey et al. 2012). The increase in global warming and changing climate is the major concern the world is facing today. Variations in climate change such as transformation in air temperature, relative humidity, rainfall, and solar radiation have killed millions of living habitats throughout the world (Chaudhary and Pandey 2019). As a result of these changes, there has been a consistent warming trend, as evidenced by the increased occurrence of extreme climate events such as droughts, floods, and heat waves (Tirkey et al. 2018). Drought is a form of severe weather that has prolonged and adverse effects on a country's agricultural output, groundwater storage, and socioeconomics (Vicente-Serrano et al. 2010). Drought monitoring data is typically recorded and applied using broad impact categories such as (1) meteorological drought, which is defined as anomalies in accumulated precipitation; (2) agricultural drought, which is defined as reduced root-zone soil moisture and crop yields; (3) hydrological drought, which is defined as low stream flow and depleted

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Delineation of Groundwater Potential Zone using Analytical Hierarchy Process

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ABSTRACT

In the present study, the groundwater potential zone was demarcated and suitable site selection for the water storage structures was identified in the Deoria watershed of Jharkhand by using analytical hierarchy process. Thematic layers of lithology, geomorphology, soil, lineament, lineament density, slope, relief, aspects, drainage, drainage density, land use and land cover, and groundwater depth maps were created. The watershed falls under fourth-order river basin. A major portion of the basin is mainly dominated by lower order streams. Groundwater potential zones were categorized as very good, good, moderate, bad, and very bad. Only 9.37% of the total watershed area falls under a very good category. Twenty-eight suitable sites were recognized for constructing water harvesting structure in the Deoria watershed. The vast majority of the Deoria watersheds were observed to be appropriate for check dam. The watershed is characterized as having a reasonable land-use class (forest, river bed), slope (under 15%) and soil type (sandy loamy topsoil) which fills the need for soil and water conservation and groundwater expansion. The appropriateness of other water storage structures like nala bandh, farm pond and bore well were apportioned on the grounds. Remote sensing, satellite data, and GIS techniques provide a convenient approach for delineating the potential of groundwater zones which ultimately support the better planning and management of groundwater resources.

INTRODUCTION

Recently annual average available water resources of India were estimated as 1869 billion cubic meters (BCM). The total available water resources were figured out as 1123 BCM. The surface water contributes 690 BCM and 433 BCM by groundwater sources. Enough storage structures are required to exploit the 690 BCM of available surface water potential. The utilizable irrigation potential is revised from 113.5 million hectares (Mha) to 139.9 Mha (CWC, 2018). Standing Sub Committee of Ministry of Water Resources, Government of India assessed the water requirement for the irrigation sector as 688 BCM in 2010, 910 BCM in 2025, and finally predicted 1072 BCM in 2050 because the agricultural sector consumes around 80% of the available water in India and the trend is likely to be continued keeping in view the cultivation of water-intensive crops (MoWR, 1999; Iyer, 2003). India receives around 400 Mha-m of yearly rainfall, out of which around 200 Mha-m are lost as evapotranspiration. Around 135 Mha-m is accessible superficially and the remaining part of precipitation meets the groundwater through permeation. Around 92 Mha-m of the accessible surface water, at last, goes to the oceans regardless of the development of vast dams, stores, check dams, water-collecting structures, and so forth (Sarangi et al., 2005)

Groundwater used to be the most important and reliable water resource for any region to improve the socio-economic conditions of the stakeholders. To provide a solution to the water scarcity problem in any region in which the disparity between exploitation and

groundwater resources are evident, it is essential to boost the groundwater potential by artificial replenishment. The water harvesting technique is still to be implemented to address the water scarcity issues. Further, the creation of storage structures to accommodate the excess flow during monsoon months can help in addressing the water shortage issues. The choice of the best location for water collecting plans must be founded on specific criteria that take into account the financial aspects and the physical attributes such as landscape, soil types, and land use of the watershed zone (Padmavathy et al., 1993). The significant components for the execution of a watershed management plan are its physiography, morphology, soil, land use/land spread, and accessible water assets (Ratnam et al., 2005). Remote sensing (RS) and geographic information system (GIS) are effective tools for the ecosystem and social and economic management. The remote sensed data provides the appropriate analysis of the study area–system functioning, pattern, and change over time at local, regional, and global scales. The development of morphometric techniques is crucial in the quantitative description of the drainage basins geometry and its networks help in labeling drainage network. The analysis of morphometric parameters using GIS has proved to be an effective method of exploring the hydrological processes of the watershed. Potential zones for groundwater can be demarcated with the use of remote sensing and GIS techniques.

Analytical Hierarchy Process (AHP) is a vital technique for the Multi-Criteria Decision Making (MCDM) process as a strategy for taking care of financial basic leadership issues (Saaty, 1980). AHP is used when measurements are free and is fit to take care of the issues including subordinate measurements (Yang et al., 2008). AHP formulates a target problem into a hierarchy, while the analytic network process (ANP) make it as a network. A system of pairwise comparisons is developed to measure the weights of the elements of the structure. The alternatives are later ranked in the decision problem. In the AHP, the criteria selected are taken to be independent of each other, however, ANP does not require independence among components. Saaty (1996) recommended the utilization of AHP to handle the issue of autonomy on choices or criteria. Many studies in the past have explored the capability of GIS and remote sensing for the identification of groundwater potential zones (Gupta and Srivastava, 2010; Gavade et al. 2011; Biswas et al., 2012; Dantis and Bhat, 2015; Sharma et al., 2016; Kolekar et al., 2017; Murmur et al., 2019; Dar et al., 2020). The thematic layer maps such as lineament density, drainage density, digital elevation model (DEM), slope map, and land use/land cover (LULC) are prepared for delineating groundwater potential zones. A multi-criteria evaluation technique has been frequently used to determine the number of choice possibilities according to the associated weight of each factor. A map is finally generated which classifies the area into normally good, moderate, and low groundwater potential zones.

An uneven rainfall distribution and poorly developed water resources storage infrastructures have caused severe hardship from time to time in the various regions. The recurrence of degradation in



Ultraslow light propagation in photorefractive SBN:75

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ABSTRACT

Slowing down of light pulses to ~ 1.9 mm/s has been obtained theoretically in SBN:75 via degenerate two-wave mixing (TWM) configuration. The optical delay has been tuned by varying the input pulse width & beam crossing angle. At the optimum beam crossing angle ($2\theta \sim 10^\circ$), very high TWM gain $\sim 10^7$ has been achieved. Maximum fractional delay (FD) of 1.04 and 0.20 is obtained for 150 ms pulse in case of SBN:75 and SBN:60 respectively. Further, the optical delay, group velocity, FWHM, pulse broadening and amplification in case of SBN:75 is compared with SBN:60. SBN:75 showed minimal pulse broadening, large amplification ($\sim 10^5$), five times more FD and two degrees of higher optical delay than that of SBN:60.

1. Introduction

Room temperature slowing down of light is a growing field of research in nonlinear optics (Han et al., 2013; Zhang et al., 2004; Matsko et al., 2000; Okawachi et al., 2005). It has potential application in all optical tunable delay lines (Lenz et al., 2001), quantum computation, high resolution interferometry (Shi et al., 2007), gravitational wave detection (Yum et al., 2008), solar cells (Deparis and Daif, 2012), and information technology (Dutton and Hau, 2004). It has been successfully generated by different techniques such as in atomic medium using EIT (Liu et al., 2001), stimulated Brillouin scattering (Okawachi, 2005), coherent population oscillation (Bigelow et al., 2003), photorefractive (PR) two-wave mixing (Zhang et al., 2004; Bo et al., 2005; Gao et al., 2006; Struman et al., 2011; Podivilov et al., 2003; Shumelyuk et al., 2004). Among above mentioned techniques PR two-wave mixing is most promising technique to generate ultraslow light at very low laser power at room temperature (Shumelyuk et al., 2004; Yeh, 1989; Chi et al., 2009). In PR crystals both sub as well as superluminal pulse propagation has been observed experimentally and estimated theoretically (Bo et al., 2005; Gao et al., 2006; Struman et al., 2011; Podivilov et al., 2003; Shumelyuk et al., 2004; Yeh, 1989; Chi et al., 2009; Yeh, 1993; Boyd, 2003; Kumari and Khare, 2012; Kumari and Khare, 2011). Slowing down of light pulses using backward four-wave mixing with local response is demonstrated in BTO crystal (Shcherbin et al., 2015). It may find application in selected spectral range for the slowing down of light pulses with different time delays. Graber et al. presented the scheme of a single beam, tunable device using fast light via beam fanning in $\text{Sn}_2\text{P}_2\text{S}_6$:

Sb (Grabar et al., 2014). Recently, Bouldja et al. demonstrated improved slow light performances using photorefractive two-wave mixing in $\text{Sn}_2\text{P}_2\text{S}_6$ (Bouldja et al., 2019).

The optical delay (slow and fast light) in PR crystals is generated by pump-probe technique (Yeh, 1989). In this technique, the pump and probe beam interfere inside the PR medium. The interference of beams results in redistribution of charge carriers inside the medium. The space charge grating via Pockel's effect causes the refractive index of the crystal to change. The non-local refractive index response results in a unidirectional transfer of intensity and phase between interfering pump and probe beams. The probe beam is amplified and shifted after travelling through the PR crystal (Yeh, 1989; Chi et al., 2009; Yeh, 1993; Boyd, 2003). Significant optical delay has been experimentally as well as theoretically observed in various PR crystals viz. BSO, BaTiO_3 , LiNbO_3 (Zhang et al., 2004; Bo et al., 2005; Gao et al., 2006; Struman et al., 2011; Podivilov et al., 2003; Shumelyuk et al., 2004). Struman and co-workers has shown theoretically and demonstrated experimentally ultraslow light ~ 0.025 cm/s in BaTiO_3 crystal using Gaussian pulse (Podivilov et al., 2003). Further, sub as well as superluminal pulse propagation has been experimentally observed in BaTiO_3 crystal using chopped pulses (Kumari and Khare, 2012; Kumari and Khare, 2011). The large optical delay in BaTiO_3 crystals is due to its greatest dynamic range for two-beam coupling (Yeh, 1993). However, due to slow response time it cannot find application in fast system.

Another promising PR crystal for optical delay application is strontium niobate (SBN) (Ewbank et al., 1987; Lenzo et al., 1967; Orlov et al., 1994). Its large electro-optic coefficient leads to very large

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Impact of Exhaust Gas Recirculation (EGR) on the Emission of the Dual-Fuel Diesel Engine with Hydrogen as a Secondary Fuel

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Abstract Hydrogen is one of the best alternatives for conventional fuels because it is free from carbon. Hydrogen has its own benefits and limitations in its use as a conventional fuel in automotive engine system. However, hydrogen increases the performance along with NO_x formation. One of the methods to reduce NO_x without comprising its performance is addition of exhaust gas recirculation (EGR). In the present investigation, the formation of carbon monoxide (CO), carbon dioxide (CO₂), un-burnt hydrocarbon (HC) and oxides of nitrogen (NO_x) was measured on four-cylinder water-cooled turbocharged direct ignition (DI) compression ignition diesel engine with diesel as a base fuel and hydrogen as a gaseous fuel (0–5%) by using EGR technique (5–10%) at various load conditions.

The formation of NO_x gets decreased by 37.82, 48.29 and 75.95% by using 5%, 10% and 15% EGR, respectively, at 40% load conditions as compared with pure diesel operation. Similarly, as the engine runs on dual-fuel modes with 5% substitutions of diesel fuel with hydrogen fuel (H₂), the formation of NO_x gets decreased by 21.16 and 29.90%, at 40% load conditions by using 5 and 10% EGR, respectively, as compared to pure diesel operation. Further,

the formation of CO, CO₂ and HC also gets decreased by the addition of 5% EGR in the gaseous–air mixture, while it increases beyond 5% EGR in dual-fuel mode conditions. The maximum quantity of the hydrogen and EGR substitution is limited due to knock in the engine.

Keywords Dual fuel · Exhaust gas recirculation · NO_x · Secondary fuel · Alternative fuel

Introduction

Diesel engine proves to be the most promising among all the efficient devices employed for transportation and energy generation purposes, on account of the better economy in fuel consumption. It is also found to be reliable, durable and simple [1, 2]. In the wake of modern scientific technologies such as vehicles running on electricity, hybrid batteries and fuel cell [3, 4], we see a rising trend in the demand for alternative fuel. The utilization of diesel fuel in the automobile sector is estimated to spike from 42 to 50 quadrillion Btu from the year of 2018 to 2040 [5].

Among the IC engines, the diesel engine is criticized due to its contribution to air pollution, caused by the carbon monoxide (CO) (30%), particulate matter (PM) (10%) and nitrogen dioxide (NO_x) (60%) emissions [6]. The exhaust emission from the diesel engine is harmful for both the environment and human life. In the past few decades, the PM and GHGs emitted from the diesel engines have been increasing enormously in the atmosphere [7]. Therefore, the improvement in the IC engines is an urgent need today, in order to make them eco-friendly and thus cater to the threats of pollution.

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Journal Pre-proof

Dietary cadmium (Cd) reduces hemocyte level by induction of apoptosis in *Drosophila melanogaster*

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Dietary cadmium (Cd) reduces hemocyte level by induction of apoptosis in *Drosophila melanogaster*

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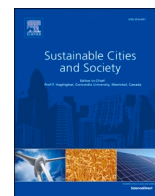
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Abstract

Drosophila melanogaster larvae ensure continuous proliferation and differentiation of hemocytes to maintain a fixed range of different blood cell types during its various stages of development. Variation in this number is often an indicator of animal well-being, its genotype or an effect of environmental perturbation, including exposure to heavy metals. The present study investigates the effect of Cd on larval hemocytes. Embryos were allowed to grow in metal media till third instar larvae and finally circulating hemocyte were collected. The number of major hemocytes, plasmatocytes and crystal cells was determined to be lowered in Cd exposed animals. Our results also showed modulation of antioxidant biology of Cd exposed hemocytes by changing the major antioxidant enzymes superoxide dismutase (SOD) and catalase (CAT)



Impact of COVID-19 induced lockdown on land surface temperature, aerosol, and urban heat in Europe and North America

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ABSTRACT

The outbreak of SARS CoV-2 (COVID-19) has posed a serious threat to human beings, society, and economic activities all over the world. Worldwide rigorous containment measures for limiting the spread of the virus have several beneficial environmental implications due to decreased anthropogenic emissions and air pollutants, which provide a unique opportunity to understand and quantify the human impact on atmospheric environment. In the present study, the associated changes in Land Surface Temperature (LST), aerosol, and atmospheric water vapor content were investigated over highly COVID-19 impacted areas, namely, Europe and North America. The key findings revealed a large-scale negative standardized LST anomaly during nighttime across Europe (-0.11 °C to -2.6 °C), USA (-0.70 °C) and Canada (-0.27 °C) in March–May of the pandemic year 2020 compared to the mean of 2015–2019, which can be partly ascribed to the lockdown effect. The reduced LST was corroborated with the negative anomaly of air temperature measured at meteorological stations (i.e. -0.46 °C to -0.96 °C). A larger decrease in nighttime LST was also seen in urban areas (by ~ 1 – 2 °C) compared to rural landscapes, which suggests a weakness of the urban heat island effect during the lockdown period due to large decrease in absorbing aerosols and air pollutants. On the contrary, daytime LST increased over most parts of Europe due to less attenuation of solar radiation by atmospheric aerosols. Synoptic meteorological variability and several surface-related factors may mask these changes and significantly affect the variations in LST, aerosols and water vapor content. The changes in LST may be a temporary phenomenon during the lockdown but provides an excellent opportunity to investigate the effects of various forcing controlling factors in urban microclimate and a strong evidence base for potential environmental benefits through urban planning and policy implementation.

1. Introduction

COVID-19, a severe acute respiratory syndrome Coronavirus 2 (SARS-CoV-2) disease, caused worldwide panic since late December 2019. The World Health Organization (WHO) has declared COVID-19 as the latest “Public Health Emergency of International Concern (PHEIC)”. The health emergency has led to rigorous nationwide containment measures (lockdowns) over more than 100 countries. Such extreme measures in social distancing, limitations of transportation, industrial production and human activities have resulted in unprecedented temporary decreases of aerosols and atmospheric pollutants (NO_2 , CO, SO_2 ,

and PM), mainly due to the confinement of combustion of fossil fuels and fumes from sclerotic traffic (Marinello et al., 2021; Muhammad et al., 2020; Wang & Li, 2021; Xu et al., 2020). Therefore, a large decrease in air pollution and positive environmental implications are reported for the first time since World War –II due to the worldwide lockdowns in awake of the COVID-19 pandemic (Evangeliou et al., 2021; Grivas et al., 2020; Singh et al., 2021). Several studies demonstrated a considerable decrease in atmospheric pollutants across urban areas worldwide due to national lockdowns (Bauwens et al., 2020; Latif et al., 2021; Wang & Su, 2020). NO_2 concentration has dropped by 20–30%, or even more, in urban centers of China (Bao & Zhang, 2020), India (Mahato et al., 2020),

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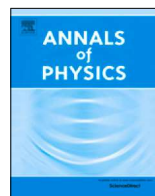
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Relativistic model for anisotropic spheres in $f(R, T)$ gravity via Karmarkar condition

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ABSTRACT

Our present work is devoted to investigate the existence of a compact stellar configuration model in the framework of $f(R, T)$ gravity theory, where R and T denote the Ricci scalar and trace of energy–momentum tensor, respectively. Here, we have developed a setup using a well-known Karmarkar condition and obtained a well-behaved embedding class-one solution with specific linear function $f(R, T) = R + 2\chi T$, where χ is the coupling constant. We obtain a specific form of differential equation by using this condition that showed a connection between e^λ and e^ν . With the viability of our stellar model, we have checked all the physical parameters such as density, pressure, speed of sound, TOV equation, redshift, etc. of compact stars like RX J1856-37, 4U1538-52, SAX J1808.4-3658, EXO 1785-248, PSR J1903+327, and Vela X-1 which are conferred in tables and graphs. And the observation suggested, our solution for compact stars using Karmarkar condition in the background of $f(R, T)$ has shown more consistency and the results are fair and appealing.

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1. Introduction

General relativity is considered as an exceptional theory that has shown compatibility within astrophysical observations. In recent period of time, the structural properties of compact objects like neutron stars have been inspected according to the GR theory. In parallel, the study of pulsars and other stars with high magnetic fields is seen as one of the greatest discoveries, in the field of

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Mapping tea plantations dynamics during 2000–2020 and monitoring biophysical attributes using multi-temporal satellite data in North Bengal (India)

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Abstract

Tea is an important cash crop, and it becomes necessary to map the spatial distribution of tea plantations. The tea industry has been expanding rapidly in the Northeast region of India, and consequently, the area under tea plantations is changing rapidly which needs periodic monitoring. In this study, satellite data such as Landsat-5 Thematic Mapper (TM) and Sentinel-2A were deployed for tea plantation identification and to analyze the dynamics of tea extent in the North Bengal district during 2000 and 2020. The result showed that the tea plantation area has increased from 1097 km² (2000) to 1377 km² (2020), depicting an increase in tea plantation area by 280 km² (or 25%) during the last 20 years. The highest increase in tea plantations was in Darjeeling (+137 km²) and Jalpaiguri (+ 83 km²) districts due to the expansion of tea estates along with the increasing population. The accuracy of tea plantation was evaluated using recall and precision with F1 score of 0.90 in 2000 and 0.92 in 2020. The tea plantation health condition was also assessed using both biophysical (LAI, EVI, FPAR) and biochemical parameters (leaf chlorophyll content). The results revealed that tea plants leaf area index (LAI) varied from 1 to 3, with healthy tea plants showed LAI > 2. Similarly, healthy tea plants depicted leaf chlorophyll content of 40 to 70 µg/cm². Assessment of dynamics of tea plantation is required for promoting sustainable tea practices and safeguarding economic and social importance of people living in North Bengal.

Keywords Tea plantation · LAI · FPAR · NAOC · Chlorophyll · Darjeeling

Introduction

Tea (*Camellia sinensis* L.) is an important leading cash crop and commonly consumed as a beverage in the world. It is a popular non-alcoholic drink for more than 66% of the world population which has several pharmacological effects, such as inhibiting tumor cells, cardiovascular diseases, anti-obesity, prevent diabetes, stabilize blood pressure, and decrease the chance of atherosclerosis (Wang et al. 2010). Globally, tea has a cultivated area of about 4.9 million ha with a total production of 5.96 million tons in 2018 (FAO 2018). Tea production regions have been expanding rapidly due to market demand (i.e., both domestic

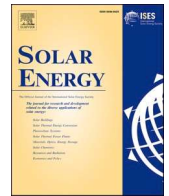
and international) at the cost of other land use, especially natural forests (Su et al. 2014). Moreover, the tea market is projected to grow with the burgeoning population in the world. So the information of tea plantations distribution and its area is essential to monitor the production of tea yield as well as environmental degradation and disturbance. As tea is a sensitive crop with respect to climatic conditions, cultivation areas are geographically restricted and mostly found in developing countries. Among tea-producing countries, the major producers are China (61%), India (13%), Sri Lanka (5%), Kenya (5%), Indonesia (2%), and Japan (1%), which account for 87% of total tea plantation area (FAO 2018). These countries account for about 77% of production and 80% of global exports (Dhekale et al. 2014).

Various government and private sectors including tea estate company need advanced information on tea plantations about their area and anticipated yield. Accurate information is therefore required for policy development. Traditionally, the survey method is not feasible due to the cost and time to monitor the distribution and area of tea plantations. Often,

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Enabling open sun cooling method-based estimation of effective concentration factor/ratio for concentrating type solar cookers

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ARTICLE INFO

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Solar concentrators
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ABSTRACT

The solar cooker is a vital device to attain sustainable development goals. Solar concentrating cookers (SCCs) are preferred mostly for intermediate to high-temperature cooking applications. The solar flux reflected and concentrated by the reflecting surface of the collector of a particular design of SCC are mainly responsible for the heating of the cooking pot/receiver. Hence, the quantification of the concentration-effect and subsequent assessment of effectiveness and role of reflecting surface in the opto-thermal performance analysis and rating of the SCCs is an essential and critical requirement.

This work proposes a thermal method to determine an Effective Concentration Ratio (C_{eff}) for any design of SCC. Two thermal tests, with and without reflecting surface, were performed on the SCC. Results depict that determination of C_{eff} allows the quantification of realistic concentration ratio and comments on the thermal and optical performance analysis of the SCC. The mean value of C_{eff} is determined as 4.998 and the geometric concentration ratio computed to be ~ 12.35 for the SCC used in the present work. This result indicates the effectiveness of the concentrating surface. Thus, C_{eff} is an effective tool to estimate the efficacy of/degradation in the performance analysis of reflecting surface of the different designs of the SCCs and can be effectively used for grading of SCCs. This method may be helpful for other solar concentrating collectors of several design configurations as well.

1. Introduction

Solar Concentrating Cookers (SCCs), used for institutional and community cooking, mainly concentrate the direct normal incident (DNI) component of the solar radiation. It enables the test loads/fluids to attain intermediate to high temperatures. The temperature achieved using a particular solar concentrating collector is characterized by the design of the collector and absorber/receiver system. For example, the point focusing solar concentrating collectors attain high temperatures compared to line focusing type collectors. Thus, the concentration-effect/ratio is the most crucial parameter in the characterization of different designs of the SCCs.

SCCs Concentration ratios are defined in two terms Geometric Concentration Ratio (C_{GCR}) and Flux Concentration Ratio (C_{FCR}). These concentration ratios were utilized extensively in the opto-thermal

analysis of SCCs. C_{GCR} is the ratio of the area of solar concentrator aperture to the area of absorber/receiver; whereas, C_{FCR} is the ratio of the solar flux on the receiver/absorber to the solar flux on the area of solar concentrator aperture (Duffie and Beckman, 2013; Yogi Goswami et al., 2003 and Kalogirou, 2009). Out of these, C_{FCR} enables to get more realistic values of concentration as it accounts for the optical losses from reflecting and refracting elements of solar collector and receiver; while, C_{GCR} provides the reasonably acceptable values of overall thermal losses from the absorber/receiver (Yogi Goswami et al., 2003).

In concentrating type solar cooker/collector, the heating of the cooking pot/receiver depends on the solar flux reflected by the collector surface and, in turn, the effect of concentration of a particular design of SCC. The solar flux available at the focus of the SCCs depends on the design (geometrical) and material (physical) parameters of the collector and receiver. Thus, minor changes/fluctuations in these parameters may alter the value of the Geometric Concentration Ratio (C_{GCR}) and/or

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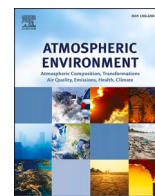
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Tracking NO₂ emission from thermal power plants in North India using TROPOMI data

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HIGHLIGHTS

- NO₂ emissions from thermal power plants in North India estimated from TROPOMI data.
- Top-down estimates show a significant correlation (R of 0.88) with bottom-up estimates.
- NO₂ emissions from the nine plants in the vicinity of Delhi varied in the range 8–30.6 kt/yr.
- 41–290% reduction during the COVID-19 lockdown relative to the previous year.

ARTICLE INFO

Keywords:

NO₂ emission
Power plants
India
TROPOMI data
Lockdown impact

ABSTRACT

Exposure to air pollution is the largest environmental health risk in India, where the coal-fed thermal power plants (TPPs) are identified as the single largest air pollution source. The key to an efficient air quality management plan is strict compliance of the TPPs with emission norms. Yet, in-situ measurements are lacking, and the bottom-up emission inventory is not periodically updated in India. Here we adopt a top-down approach to estimate NO₂ emission from nine TPPs within 300 km of the megacity Delhi using TROPospheric Monitoring Instrument (TROPOMI) data. We first estimate the NO₂ lifetime for each TPP using an e-folding decay length along the wind direction and combine it with the NO₂ columnar molecular density to estimate the NO₂ emission. Our estimates show a correlation coefficient of 0.88, and a root mean square error of 4.15 kt/year with the ECLIPSE V5 bottom-up inventory. NO₂ emission in these TPPs varied in the range of 8.0–30.6 kt/year with considerable seasonal variability. Using this data, we report a decrease in NO₂ emission in the range 41%–290% during the COVID-19 lockdown period relative to the same period in the previous year. As India launched the National Clean Air Program to control air pollution, our method would be highly useful in tracking the emission compliance of the TPPs across the country.

1. Introduction

Air pollution exposure is one of the leading health risk factors in India (Cohen et al., 2017). To minimize the staggering health burden of air pollution in India (Balakrishnan et al., 2019), the Government of India has launched the National Clean Air Programme (NCAP) in 2019 that has set a target of reducing particulate matter concentration in 2024 by 30% relative to the level in 2017.

Coal-combustion in thermal power plants (TPPs) and for domestic use is a major air pollution source in India (Gao et al., 2018; GBD MAPS Working Group, 2018). In India, coal is the primary choice as a fuel

for power generation because of its easy availability (Guttikunda and Jawahar, 2014). According to the Central Electricity Authority of India (CEA) 2019 report (http://www.cea.nic.in/reports/others/planning/pdm/list_power_stations_2019.pdf), India's total capacity of electricity generated by thermal, hydro, and nuclear power plants are 226.2 GW (81.2%), 45.4 GW (16.3%), and 6.8 GW (2.5%), respectively. Within TPPs, 88.9% of power is generated using coal as fuel, and the rest is from gas and diesel. Most of India's coal-fired TPPs use bituminous coal, which is the second standard coal after anthracite. The rest uses lignite coal, soft brown coal containing a high amount of water (after peat), and is the second most polluting coal type (Man et al., 2015).

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