सत्यमेव जयते

GOVERNMENT OF WEST BENGAL

GOVERNMENT GENERAL DEGREE COLLEGE, SINGUR

ESTD.2013

OFFICE OF THE PRINCIPAL

JALAGHATA, SINGUR, HOOGHLY, W.B. 712409

Phone & Fax : +91 2630-0126, E-mail : oicsingur@gmail.com

Ref. No..... *Date.....*

3.5.1. Number of functional MoUs/Linkages with Institutions/industries in India and abroad for internship, on-the-job training, project work, student/faculty exchange and collaborative research during the last five years

As per DVV we accept that in this metric we inadvertently put 12 HEI inputs some of which did not continued more than one year, though it was not mentioned SOP. Among the 12 HEI inputs, 4 HEI inputs considered. We now claim 12 in this matric as

(i) One (1) of such program claimed in SSR lasted more than four years (2020-2023)
(ii) Seven (7) Research Collaborations earlier not claimed in SSR is included with necessary documents.

Research and other collaborations-

Sl. No.	Name	Date
1	Collaborations of **Dr. Susanta Nath** with faculty of Sidho-Kanho-Birsha University	01.08.2017- present
2	Collaborations of **Dr. Monohar Hossain Mondal** with faculty of M.M.A.M.C. Tribhuvan University, Biratnagar, Nepal	12.03.2018 - present
3	Collaborations of **Dr. Debabrata Adak** with faculty of Saha Institute of Nuclear Physics, Kolkata	10.05.2018 - present
4	Collaborations of **Dr. Piyali Bhar** with faculty of Durban University of Technology, Durban, South Africa	15.05.2019 - present
5	Collaborations of **Dr. Santanu Chakrabarti** with faculty of St. Xaviers University	20.05.2019- present
6	Collaborations of **Dr. Piyali Bhar** with faculty of Birla Institute of Technology & Science, Pilani, Hyderabad	20.05.2019 - present
7	Collaborations of **Dr. Piyali Bhar** with faculty of Jadavpur University, Kolkata	24.05.2019 - present
8	Collaborations of **Dr. Amrit Krishna Mitra** with faculty of TIFR, Mumbai	08.12.2019 - present

Chaitali Chanda

IQAC Co-Ordinator
Government General Degree College, Singur

Coordinator
IQAC
Govt. General Degree College
Singur

Principal
Government General Degree College, Singur

Principal
Govt. General Degree College, Singur

MEMORANUM OF UNDERSTANDIG

This Memorandum of understanding (herein after called the MoU) is signed on the 1st Day of August, 2017 between **DR. SUSANTA NATH**, Associate Professor of Zoology, Government General Degree College, Singur and **DR. BIPLOB KUMAR MODAK**, Professor of Zoology, Sidho-Kanho-Birsha University, Purulia, West Bengal about **Research Collaborations** in the field of Bio-ecology and Toxicology of *Chironomus*, a beneficial insect as bioindicator of aquatic pollution and nutritious fish food.

Clauses of MoU:

Both the signing parties will follow Research ethics, share ideas, cooperate in laboratory based studies and will not show any conflict of interest while publishing any documents or research articles.

Time period of Collaboration

This collaboration MoU will remain in vogue until one of the signing party wishes to withdraw himself from the MoU by writing his unwillingness.

Signed:

Susanta Nath

1.First Party :

Dr. Susanta Nath

Dr. Susanta Nath, W.B.E.S.
Associate Professor of Zoology
West Bengal Education Service
G.G.D. College, Singur
Hooghly-712409

2. Second Party:

Biplob Kumar Modak

Dr. Biplob Kumar Modak

Professor
Department of Zoology
Sidho-Kanho-Birsha University
Ranchi Road, Purulia
West Bengal-723104

Functionality of the MOU

Within the purview of the MOU signed between Dr.Susanta Nath, Associate Professor of Zoology, Government General Degree College, Singur and Dr. Biplob Kumar Modak, Professor of Zoology, Sidho-Kanho-Birsha University, Purulia, West Bengal the following outcomes were obtained:

1. Six (06) **Research Publications** in Peer reviewed Journals (two with Impact Factor 4.996 and 0.96 respectively) during 2017-2022. All journals are UGC approved. They also published a book chapter jointly.

2. Mr. Rahul Podder has awarded Ph.D. Degree under joint Supervision of Dr. Biplob Kumar Modak and Dr. Susanta Nath.

3. They also presented their research works in many symposia jointly.

Signed:

Dated the 24th June, 2022

Susanta Nath

1.Dr. Susanta Nath

Dr. Susanta Nath, W.B.E.S.
Associate Professor of Zoology
West Bengal Education Service
G.G.D. College, Singur
Hooghly-712409

Biplob Kumar Modak

2. Dr. Biplob Kumar Modak

Dr. Biplob Kumar Modak

Professor
Department of Zoology
Sidho-Kanho-Birsha Univers
Ranchi Road, Purulia
West Bengal-72

SIDHO-KANHO-BIRSHA UNIVERSITY

PURULIA

Certified that **Rahul Podder** *was admitted to the Degree of Doctor of Philosophy (Science) in* **Zoology** *of the University on* **07.10.2021** *and that the degree was awarded to* **him** *with all the Rights and Privileges thereto appertaining.*

Purulia
The 23rd February, 2022

Vice - Chancellor

scientific reports

Check for updates

OPEN

Tube length of chironomid larvae as an indicator for dissolved oxygen in water bodies

Rahul Podder[1], Susanta Nath[2]✉, Biplob Kumar Modak[1], Lennart Weltje[3] & Biswanath Malakar[4]

Tube-building larvae of non-biting midges, or chironomids, are considered bioindicators of water pollution. The larvae use benthic particles to make their tubes and create a respiratory current with the movement of their bodies inside the tubes. The tube length of the chironomid larvae varies depending on several physicochemical properties of the aquatic medium. Here we study the role of physicochemical parameters on the tube length from different field sites and in the laboratory. It appears that among different physicochemical factors, dissolved oxygen (DO) has a major role in determining the tube length of the larvae. A quantitative relationship between oxygen concentration and the tube length of larvae is presented here. Our study reveals a longer tube in aquatic media with oxygen deficiency and a shorter tube in those with higher oxygen. This result may help to assess the quality of water bodies and, in particular the status of DO.

Chironomids (Diptera: Chironomidae) play a major role in the aquatic food chain by maintaining a link between producer and primary carnivores. They are also considered as important biological tools for environment assessment. Chironomids are primary consumers and a source of food for the higher trophic levels[1]. Tube building is an important characteristic feature of chironomid larvae and the tubes protect the larvae from the effects of heavy metals and other pollutants to some extent[2,3]. Larvae make their tubes with salivary silk and soft benthic particles[4]. The composition of the tube of the larvae is similar to the benthic particles of the surrounding medium. The quality of building materials is more important than the size of particles, in upstream of lotic water[5]. Tubes help to collect food particles, assist larvae in producing respiratory currents, act as a refuge from predators and inhibit chemical toxicants[6–8]. Halpern et. al. reported tubes of these larvae protect them from predation by damselflies[9].Tube building properties also can modify the quality of the substrate used for tube building[10]. As a bio-indicator species, larvae are used to understand the quality of the aquatic body. *Chironomus plumosus* and *Polypedilum* sp. have a great influence on de-nitrification and nitrogen turnover in lake deposits[11]. Different physicochemical factors such as water temperature, alkalinity, and benthic soil organic carbon have been found to influence the seasonal variation of body protein and the growth of chironomid larvae[12,13]. At the same time, some environmental parameters also influenced the tube-building ability of the chironomids. During the study, a strong relation between the tube length and DO was observed. As well as this feature will help the person who is involved in freshwater aquaculture to measure the DO by a standard scale without using any expensive instrument or titrimetric method. Keeping these features in mind, here an attempt has been made to find out the relationship between tube length and dissolved oxygen (DO).The work seems to be unique and novel for its own kind.

Materials and methods

The Kanchrapara wastewater canal (KWC) (22°93 N, 88°47 E) and Kanchrapara fish culturing pond (KFP) (22°94 N, 88°45 E), Kanchrapara, North 24 Parganas, West Bengal, India, are chosen for this experiment in natural conditions to study the relationship between the tube length of chironomid larvae and different physicochemical parameters of the aquatic bodies. The distance between two water bodies is approximately five kilometres, and these water bodies may be an ideal model for the urban aquatic ecosystem due to their different quality of water. KWC is enriched with a high organic and nutritive content. Because of the fish culture in KFP,

[1]Department of Zoology, Sidho-Kanho-Birsha University, Purulia, West Bengal 723 104, India. [2]Department of Zoology, Government General Degree College Singur, (University of Burdwan), Hooghly, West Bengal 712 409, India. [3]BASF SE, Agricultural Solutions-Ecotoxicology, Speyerer Strasse 2, 67117 Limburgerhof, Germany. [4]Department of Anthropology, Government General Degree College Singur, (University of Burdwan), Hooghly, West Bengal 712 409, India. ✉email: nathsusanta2012@gmail.com

Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci.
https://doi.org/10.1007/s40011-022-01377-9

RESEARCH ARTICLE

Ex-situ Evaluation of Chironomid Larvae as a Potential Supplementary Food in Aquaculture

Susanta Nath[1] · Shreya Samanta[1] · Rahul Podder[2] · Lennart Weltje[3] · Biplob Kumar Modak[2]

Received: 18 July 2021 / Revised: 10 October 2021 / Accepted: 15 March 2022

Abstract Due to the steady growth of the human population, the demand for fish as dietary protein increases globally. Though sea fishes are the main source of fish protein, freshwater fishes also occupy a significant part of the global market. There is a need to improve the nutritional value of freshwater edible fishes along with their production. The present study investigates the role of chironomid larvae as an alternate fish feed and their influence on the nutritional value of fish. Experiments were conducted with banded gourami (*Trichogaster fasciata*) fed on larvae of the aquatic insect *Chironomus striatipennis* (F1 diet), dry commercially available *Tubifex* (F2 diet), and commercially available dry granular fish food (F3 diet). The results show that total protein content is higher and cholesterol level is lower in fish fed on the F1 diet in comparison to fish fed on other diets. Moreover, the fish fed on the F1 diet contains a lower amount of free fatty acids and adequate amounts of saturated and unsaturated fatty acids. Comparing the ω6:ω3 and ω3:ω6 ratios it appears that the fish fed on the F1 diet is a better source of nutrition than fish fed on F2 and F3 diets, respectively. The high amount of palmitoleic acid, DHA and EPA in fish fed on the F1 diet, established *C. striatipennis* larvae as a suitable food source for *T. fasciata* culturing, as well as ascertaining this fish species to be a nutritious food source for humans.

Keywords Blood worm · Fish food · Protein · Fatty acids · Cholesterol

Significance statement Artificial fish foods are responsible for doing considerable harm to the water quality and are costly a little bit. Chironomids as natural fish food may be helpful to maintain water qualities and fish productivity and it is cost-effective too.

Introduction

In the life cycle of *Chironomus* sp., the larval stages, commonly known as blood worm (4th instar), are spent in the aquatic ecosystem. Due to benthic habitat, this insect has an important role in the trophic chain of water bodies by maintaining a link between detrivores and primary carnivores [1, 2]. The protein content of chironomid larvae might vary with location and the nature of the water body [3, 4]. Chironomid larvae are rich in protein and fat and also a good source of iron. Catla fed on frozen chironomid larvae showed high consumption, absorption, and a high metabolic rate [5]. Chironomid larvae are considered a good nutrient as these larvae contain lipids, proteins, fatty acids, and vitamins, which are essential for the growth of fingerlings and amino acids present in these larvae act as a supplementary component for supporting juvenile fish growth [6, 7]. *Trichogaster fasciata* has the highest lipid content in comparison to other small indigenous fishes. This fish is both commercially and ecologically important. It is sold in the market for food and ornamental fish and used in the aquatic system for bio-control of mosquito larvae. This fish is popular for its palatability with high nutritional value. It has high demand in the local market

✉ Susanta Nath
nathsusanta2012@gmail.com

1 Department of Zoology, Government General Degree College Singur (University of Burdwan), Hooghly, West Bengal 712409, India

2 Sidho Kanho Birsha University, Purulia, West Bengal 723104, India

3 BASF SE, Agricultural Solutions–Ecotoxicology, Speyerer Strasse 2, 67117 Limburgerhof, Germany

Published online: 28 May 2022

Proc Zool Soc (Jan-June 2017) 70(1):88–91
DOI 10.1007/s12595-015-0146-7

SHORT COMMUNICATION

Seasonal Trend of Body Protein and Growth of Chironomid Larvae

Susanta Nath[1] · Rahul Podder[1] · Biplob Kumar Modak[2]

Received: 29 November 2014 / Revised: 27 March 2015 / Accepted: 13 April 2015 / Published online: 13 May 2015

Abstract Chironomid midges technically named blood worms are known as useful live food for higher aquatic organism like fish. Present study deals with the seasonal variations of total body protein and the growth rates of chironomid larvae occurring in two water bodies of West Bengal, India. Analysis of the data revealed that the amount of body protein and the growth rate of larvae are higher during summer and monsoon. Comparative analysis of the data, indicates that the entire phenomenon depends on nutrient cycle of the water bodies which is influenced by a number of factors such as water temperature, alkalinity and soil organic carbon.

Keywords Chironomidae · Seasonal variation · Limnological factor · Body protein · Growth

Introduction

The benthic insects chironomids living in running and still waters, play important role in the aquatic food web (Epler 2001; CheSalmah and Hassan 2002; Cranston 2004). Adult Chironomids do not bite and avoid feeding during their short life time (Armitage et al. 1997). Chironomid larvae are well known dietary resource in fisheries (Shaw and Mark 1980) because of excellent source of protein (De La Noue and Choubert 1985), lipid, vitamins and minerals (Mclarney et al. 1974; Habib et al. 1997). The larval stages of majority of chironomid species are benthic and utilize detritus, suspended materials and sediment as resources for nest building materials and food (Ashe et al.1987). Chironomids like other benthic insects of fresh water ecosystem are dependent on sedimentation for their food supply (Brinkhurst 1974). Seasonal changes in the food habit affect physiological and biochemical parameter of chironomids (Jonasson 1972). The immature stages of the chironomid midges are abundant in wide range of lentic and lotic habitats in West Bengal, India (Chaudhuri and Guha 1987; Nandi et al. 2012). In this study an attempt has been made to correlate the length of larval individuals in respect to their body protein in relation to some limnological parameters of two contrasting water bodies, one being fresh water pond and the other is recognized as waste water canal.

Materials and Methods

Study Area

The study was carried out in the waste water canal locating at Kanchrapara (KWC), (22°56′18.6648″N, 88°28′10.0344″E) and the fresh water pond locating at Beliaghata Road (BFP), (22°33′40.9320″N, 88°24′16.8444″E) District North Twenty four Parganas, West Bengal, India.

Collection of Chironomid

Twenty different places were selected randomly and wooden squares (12″ × 12″) were placed on both sides of canal (ten quadrats on each side, 10 × 2 = 20) and the

✉ Susanta Nath
susanta_nath@yahoo.com

[1] Department of Zoology, Bidhannagar College (Govt. of W.B., India), EB-2, Salt Lake, Kolkata 700 064, West Bengal, India

[2] Department of Zoology, Sidho Kanho Birsha University, Purulia, West Bengal, India

Proc Zool Soc (Jan-Mar 2020) 73(1):95–98
https://doi.org/10.1007/s12595-019-00301-w

SHORT COMMUNICATION

An Approach to Measure the Biomass of Bloodworms (Diptera: Chironomidae) in Different Nutrients

Rahul Podder[1] · Susanta Nath[2] · Biplob Kumar Modak[1]

Received: 4 January 2018 / Revised: 19 June 2019 / Accepted: 1 July 2019 / Published online: 19 July 2019

Abstract Due to their rich nutrient content, late stage Chironomus larvae or bloodworms are considered as the most preferred natural food source of cultured fish. However, it is not popular due to its high cost and low availability. Bloodworm culture is still in its infant stage and mainly therefore harvested from nature. The objective of the study was to achieve a cost-effective culture practice of this insect under laboratory conditions. For this experiment four types of diets were selected, namely, dried potato peel powder (F1), commercial baker's yeast powder (F2), a mixed culture medium (F3) and commercial fish food powder (F4) along with a control culture medium. The result showed a significant effect of diet on both wet mass [$F = 40937.78 > F_{0.01}$ (3, 8)] and biomass [$F = 13882.84 > F_{0.01}$ (3, 8)] of bloodworms. The biomass was almost similar when larvae were fed commercial fish food and mixed diet respectively, but the mixed diet was more cost effective and a rich source of both carbohydrates and protein.

Keywords Chironomids · Diet · Culture · Biomass

✉ Susanta Nath
susanta_nath@yahoo.com

[1] Department of Zoology, Sidho-Kanho-Birsha University, Purulia, West Bengal 723 104, India

[2] Department of Zoology, Government G.D. College Singur, Singur, West Bengal 712 409, India

Introduction

Natural food for fish is more advantageous than artificial food due to its high water content, easy digestibility and presence of digestible protein. Natural live food is mobile and fishes are attracted to this type of food. Moreover, water becomes dirty due to rejected particles of artificial fish food, whereas, rejection rate of natural live food is lesser in comparison (Bogut et al. 2007). Chironomus larvae are considered as natural food for different freshwater fishes (Medeiros and Arthington 2008; Broyer and Curtet 2011). This insect performs a significant role in aquatic trophic chain by making connection between producers and secondary consumers (Tokeshi 1995). Protein content in larvae is more than fifty percent and varies with the physico-chemical parameters of water (Thipkonglars et al. 2010; Nath et al. 2017). As a fish food, though bloodworm is very nutritious, the production of this worm is very expensive so they are mainly harvested from nature (Sulistiyarto et al. 2014). It was reported that fishes on chironomus larvae were found to grow faster and spawned early. Moreover, larvae are used as live food for many aquarium fishes and their artificial culture is a challenge in the field of aquaculture (Kumar 2016; Failla et al. 2015). This insect has the ability to increase their numbers due to high production rate. It is able to compete with other benthic organisms for shelter and food and has a high tolerance of environmental changes (Kuvangkadilok 1994; Taenzler et al. 2007; Howarth and Oishi 2013). So far researchers have tried to invent various economically efficient techniques to culture this insect in laboratory as well as for commercial purposes (Habib et al. 1997). Very few studies were conducted to measure the biomass of chironomid exposed to different food media. Considering the importance of chironomid as good nutrient source for

UTTAR PRADESH JOURNAL OF ZOOLOGY

38(1): 20-25, 2018
ISSN: 0256-971X (P)

A STUDY ON THE GROWTH AND BIOMASS OF CHIRONOMUS LARVAE IN DIFFERENT FOOD MEDIA

RAHUL PODDER[1], SUSANTA NATH[2*], CATERINA FAGGIO[3] AND BIPLOB KUMAR MODAK[1]

[1]Department of Zoology, Sidho-Kanho-Birsha University, Purulia, 723 104, West Bengal, India.
[2]Department of Zoology, Government General Degree College Singur, 712 409, West Bengal, India.
[3]Department of Chemical, Biological, Pharmaceutical and Environmental Sciences, University of Messina, Italy.

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between all authors. Author RP designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors SN and BKM managed the analyses of the study. Author CF managed the literature searches. All authors read and approved the final manuscript.

ARTICLE INFORMATION

Editor(s):
(1) Marcelo Abidu Figueiredo, Department of Animal and Human Anatomy, Institute of Biological and Health Sciences, Federal Rural University of Rio Janeiro, Brazil.
(2) Idika Kalu Idika, Department of Veterinary Parasitology and Entomology, University of Nigeria, Nigeria.
Reviewers:
(1) E. Mennan Yildirim, Aydın Adnan Menderes University, Turkey.
(2) Khalid Shawky Hamadah, Al-Azhar University, Egypt.

Received: 4th April 2018
Accepted: 8th June 2018
Published: 14th June 2018

Original Research Article

ABSTRACT

Chironomid larvae, popularly known as bloodworm, are considered as preferred food for cultured fish due to their high nutritional content. However, due to less availability and high cost of production, such food is not popular so far. Here, an attempt was made to increase the biomass as well as growth of this insect at low cost. Four culture media were prepared for *Chironomus striatapennis*, using the following, Potato Peel Powder, Bakery Yeast, mixture of Potato peel powder and Bakery yeast, and Commercial Fish Food, as well as along with a Control medium containing natural pond soil and water. The study revealed that production of biomass and growth of bloodworms were higher in the mixed as well as in the medium containing fish food. But, mixed culture medium was considered better than the other three media as well as the control. As potato peel powder, a vegetable waste and bakery yeast are almost of no cost material, giving high yield when biomass of chironomid larvae was concerned.

Keywords: *Chironomus*; body growth; biomass; culture medium; cost effective.

1. INTRODUCTION

The genus *Chironomus* (Order: Diptera; Family: Chironomidae) is the most abundant and widespread members of the bottom mud communities in ponds and lakes, and play a major role in the aquatic food webs, representing a major link among producers and secondary consumers [1]. *Chironomus* larvae are

*Corresponding author: Email: susanta_nath@yahoo.com;

Asian Journal of Biology

5(4): 1-5, 2018; Article no.AJOB.40933
ISSN: 2456-7124

Response of *Chironomus striatapennis* Larvae Exposed to Three Heavy Metals

Rahul Podder[1], Susanta Nath[2*], Biplob Kumar Modak[1] and Sudipta Das[3]

[1]Department of Zoology, Sidho-Kanho-Birsha University, Purulia, 723 104, West Bengal, India.
[2]Department of Zoology, Government G.D. College, Singur, 712 409, West Bengal, India.
[3]Department of Zoology, Durgapur Government College, 713 214, West Bengal, India.

Authors' contributions

This work was carried out in collaboration between all authors. Author RP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SN and BKM managed the analyses of the study. Author SD managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJOB/2018/40933
Editor(s):
(1) Paola Angelini, Department of Chemistry, Biology and Biotechnology, University of Perugia, Perugia, Italy.
Reviewers:
(1) Ajayi O. Eunice, Federal University of Technology, Nigeria.
(2) U. D. Enyidi, Michael Okpara University of Agriculture, Nigeria.
(3) Esraa Ashraf Ahmed ElHawary, Ain Shams University, Egypt.
Complete Peer review History: http://www.sciencedomain.org/review-history/24318

Short Communication

Received 10th February 2018
Accepted 18th April 2018
Published 25th April 2018

ABSTRACT

In this experiment, estimation of LC_{50} of Lead (Pb), Cadmium (Cd) and Mercury (Hg) was carried out when *Chironomus striatapennis* was exposed to different treatment doses. Chi square was used to test for heterogeneity and the result was found to be significant ($p<0.05$) in all three metals. Fourth instar larvae were collected from breeding aquarium under laboratory conditions and exposed for 96 hours to different doses of Pb, Cd and Hg for static bioassay to measure the LC_{50}. Ten fourth instar larvae were placed in 100 ml beaker with 50 ml of each test solution. Larvae were exposed to six different concentrations, consisting of five trials. A control was also maintained wherein organisms were exposed to distilled water. Larvae were not fed during the toxicity tests. All beakers were free from tube forming materials. Data of mortality were subjected to probit analysis. Results showed that sensitivity of larvae to metals was Hg> Cd >Pb. *C. striatapennis* showed noticeable response in LC_{50} study and was sensitive to low doses of heavy metals. Several secondary consumers have preferred this larva as their food. So unplanned industrialization may increase the level of heavy

*Corresponding author: E-mail: susanta_nath@yahoo.com;

MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding (hereinafter called the MOU) is signed on the **12th Day of March, 2018** between **Dr. Monohar Hossain Mondal, WBES,** Assistant Professor in Chemistry, **Govt. General Degree College, Singur, West Bengal, India-712409** and **Prof. Dr. Ajaya Bhattarai,** Professor, Department of Chemistry, **M.M.A.M.C. Tribhuvan University, Biratnagar, Nepal-56613** about Research Collaborations in the field of Bio-Inorganic and Homogenous Catalysis using Natural/Conventional Surfactants.

Clauses of the MOU

1. Both the signing parties will follow Research ethics, share ideas, co-operate in laboratory based studies and will not show any conflict of interest while publishing any documents or research articles.
2. Both the parties will utilise Research infrastructure/funds/grants whatsoever from any sources available for the fulfilment of projects.

Time period of the Collaboration

This collaborating MOU will remain in vogue until one of the signing party wishes to withdraw himself from the MOU.

Signed:

1. First Party:

Monohar Hossain Mondal

(Dr. Monohar Hossain Mondal)

Dr. Monohar Hossain Mondal, WBES
Assistant Professor (Grp. A)
Department of Chemistry
Govt. General Degree College, Singur

2. Second Party:

Ajaya Bhattarai

(Prof. Dr. Ajaya Bhattarai)

Dr. Ajaya Bhattarai
Professor
Department of Chemistry
M.M.A.M.C, Tribhuvan University
Nepal -56613

FUNCTIONALITY OF THE MOU

Within the purview of the MOU signed between **Dr. Monohar Hossain Mondal, WBES,** Assistant Professor in Chemistry, **Govt. General Degree College, Singur, West Bengal, India-712409** and **Prof. Dr. Ajaya Bhattarai,** Professor, Department of Chemistry, **M.M.A.M.C. Tribhuvan University, Biratnagar, Nepal-56613** about Research Collaborations in the field of Bio-Inorganic and Homogenous Catalysis using Natural/Conventional Surfactants, the following outcomes were obtained:

1. **Six (06) Research articles** in International Peer-Reviewed journals have been published during 2018-2022 where few Research Fellows of Prof. Bhattarai are Co-authors.
2. Currently one Project on the **"Studies on Organic dye-natural surfactants interaction and probable remediation "**
3. More Research Projects are in discussion phase and projected to be done further.

Signed:

Dated the 27th June, 2022

Monohar Hossain Mondal

(Dr. Monohar Hossain Mondal)

Dr. Monohar Hossain Mondal, WBES
Assistant Professor (Grp. A)
Department of Chemistry
Govt. General Degree College, Singur

Ajaya Bhattarai

(Prof. Dr. Ajaya Bhattarai)

Dr. Ajaya Bhattarai
Professor
Department of Chemistry
M.M.A.M.C, Tribhuvan University
Nepal -56613

RSC Advances

REVIEW

View Article Online
View Journal | View Issue

Cite this: RSC Adv., 2021, 11, 33004

Scientific information about sugar-based emulsifiers: a comprehensive review

Aniruddha Pal, [a] Monohar Hossain Mondal, [ab] Achyut Adhikari, [c] Ajaya Bhattarai [*d] and Bidyut Saha [*a]

The instantaneous demand for foods, detergents, cosmetics, and personal care products that can be commercialized with value-added benefits including natural origin, environmental friendliness, and sustainability is increasing day by day. Accordingly, the associated industries are trying to identify bioactive ingredients that may be natural alternatives to synthetic ones. This review article is mainly aimed at the classification of natural saccharide-based emulsifiers (which are mainly bio-surfactants), their methods of preparation and their various types of applications in daily life activities. Different routes of production of mono and polysaccharide-based emulsifiers and their industrial advantages are exclusively highlighted. The readers can get an approach on how sugar-based emulsifiers are synthesized and used in the pharmaceutical, food, and personal care industries to contribute excellent physicochemical properties and feature excellent functional characteristics. Many of the synthetic procedures are associated with the use of natural ingredients to prepare emulsions concerning "eco-friendly" selective materials. In this report, an endeavour has been made towards contextual examples for the production methods of some saccharide-based emulsifiers and their advantages in various fields.

Received 27th June 2021
Accepted 20th September 2021

DOI: 10.1039/d1ra04968b

rsc.li/rsc-advances

1. Introduction

The development of science and technology is mainly focused on the security and safety of the environment, people, and ecosystem.[1] The diverse and conventional chemistry requires convenient alterations that promote the applied aspect of 'green chemistry' in the daily life activities of our community. Natural resources have been proved to be the most effective and dependable alternatives to accelerate the 'green chemistry' worldwide. In this context, species having properties such as

[a]Homogeneous Catalysis Laboratory, Department of Chemistry, The University of Burdwan, Burdwan-713104, WB, India. E-mail: bsaha@chem.buruniv.ac.in
[b]Chemical Sciences Laboratory, Government General Degree College, Singur, Hooghly 712409, WB, India
[c]Central Department of Chemistry, Tribhuvan University, Kirtipur, Nepal
[d]Department of Chemistry, M.M.A.M.C., Tribhuvan University, Biratnagar, Nepal. E-mail: ajaya.bhattarai@mmamc.tu.edu.np

Aniruddha Pal was born in Burdwan, India in 1996. He has passed his MSc from The University of Burdwan and is currently working as a JRF under the supervision of Prof. Bidyut Saha in the Department of Chemistry at Burdwan University, WB, India.

Dr Monohar Hossain Mondal was born in West Bengal, India in 1991. He has completed his PhD degree from The University of Burdwan in 2017 from the Bioremediation Laboratory (The University of Burdwan). He is currently appointed as Education Service Officer by the Government of West Bengal and presently working as Assistant Professor in Chemistry at Government General Degree College Singur, Hooghly, WB, India. He has published many international peer-reviewed scientific articles on surfactant chemistry.

polymers

MDPI

Review

A Review of Biopolymers' Utility as Emulsion Stabilizers

Nirmala Tamang [1], Pooja Shrestha [2], Binita Khadka [2], Monohar Hossain Mondal [3,*], Bidyut Saha [4,*] and Ajaya Bhattarai [1,*]

1 Department of Chemistry, Mahendra Morang Adarsh Multiple Campus (M.M.A.M.C.), Tribhuvan University, Biratnagar 56613, Nepal; nt891840@gmail.com
2 Central Department of Biotechnology, Tribhuvan University, Kirtipur 44618, Nepal; shrestha.pooja2012@gmail.com (P.S.); khadkabinita1000@gmail.com (B.K.)
3 Chemical Sciences Laboratory, Government General Degree College, Singur 712409, India
4 Homogeneous Catalysis Laboratory, Department of Chemistry, The University of Burdwan, Burdwan 713104, India
* Correspondence: mmondal1208@gmail.com (M.H.M.); bsaha@chem.buruniv.ac.in (B.S.); ajaya.bhattarai@mmamc.tu.edu.np (A.B.)

Abstract: Polysaccharides, polynucleotides, and polypeptides are basic natural polymers. They have various applications based on their properties. This review mostly discusses the application of natural polymers as emulsion stabilizers. Natural emulsion stabilizers are polymers of amino acid, nucleic acid, carbohydrate, etc., which are derived from microorganisms, bacteria, and other organic materials. Plant and animal proteins are basic sources of natural emulsion stabilizers. Pea protein-maltodextrin and lentil protein feature entrapment capacity up to 88%, (1–10% concentrated), zein proteins feature 74–89% entrapment efficiency, soy proteins in various concentrations increase dissolution, retention, and stability to the emulsion and whey proteins, egg proteins, and proteins from all other animals are applicable in membrane formation and encapsulation to stabilize emulsion/nanoemulsion. In pharmaceutical industries, phospholipids, phosphatidyl choline (PC), phosphatidyl ethanol-amine (PE), and phosphatidyl glycerol (PG)-based stabilizers are very effective as emulsion stabilizers. Lecithin (a combination of phospholipids) is used in the cosmetics and food industries. Various factors such as temperature, pH, droplets size, etc. destabilize the emulsion. Therefore, the emulsion stabilizers are used to stabilize, preserve and safely deliver the formulated drugs, also as a preservative in food and stabilizer in cosmetic products. Natural emulsion stabilizers offer great advantages because they are naturally degradable, ecologically effective, non-toxic, easily available in nature, non-carcinogenic, and not harmful to health.

Keywords: emulsion stabilizer; nanoemulsion; emulsion technology; biopolymer

Citation: Tamang, N.; Shrestha, P.; Khadka, B.; Mondal, M.H.; Saha, B.; Bhattarai, A. A Review of Biopolymers' Utility as Emulsion Stabilizers. *Polymers* **2022**, *14*, 127. https://doi.org/10.3390/polym14010127

Academic Editor: Ki Hyun Bae

Received: 14 November 2021
Accepted: 22 December 2021
Published: 30 December 2021

1. Introduction

"Biopolymers are natural sources polymers which are obtained either synthesized chemically from a biological material or biosynthesised entirely by living organisms" [1], such as proteins (amino acid polymers), genetic material (nucleic acid polymers), glycoforms (carbohydrate polymers and glycosylated molecules), metabolites, and other structural molecules. These polymers can be incorporated in two different ways, depending on whether they are surface-active (most proteins) or surface-inactive (most polysaccharides) [2]. They perform several functions such as coating, packaging, and many other mechanical functions, according to their properties. They are biodegradable and do not accumulate like many other synthetic polymers, such as waste plastics [3].

The emulsification properties of polymers are based on their monomer units and are used in a variety of ways depending on their basic features in different fields, such as food, pharmaceuticals, cosmetics, pesticides, fertilizers, etc. The overall biopolymer types are listed in Figure 1.

RSC Advances

REVIEW

View Article Online
View Journal | View Issue

Cite this: RSC Adv., 2022, 12, 9139

A comprehensive review on the sources, essentiality and toxicological profile of nickel

Wasefa Begum, [a] Summi Rai, [b] Soujanya Banerjee,[a] Sudip Bhattacharjee, [c] Monohar Hossain Mondal, *[c] Ajaya Bhattarai *[b] and Bidyut Saha *[a]

This review contains up-to-date knowledge and recent advancements on the essentiality, sources, and toxicological profile of nickel and its different compounds. Nickel is a recognized essential element for several important biological processes like the healthy growth of plants, animals, and soil/water microbes; though an excess amount of nickel intoxicates flora and fauna. Nickel is found to affect the photosynthetic function of higher plants; it can severely degrade soil fertility and causes many chronic diseases in humans. Due to the huge growth in the nickel industry and consumption of nickel-containing products, environmental pollution has become inevitable by the element nickel and also varieties of its by-products through all the phases of making, utilization and dumping. We have focused on the importance of agenda 2030 (UN 17 SDGs) during the preparation of the write-up and have highlighted goals 3, 6, 8, 9, 11, 12, 13, 14, and 15 by elaborately discussing associated points. The plausible molecular mechanism of nickel toxicity is presented in simple diagrams. The article elaborates on possible methods for remediation of nickel toxicity and the treatment of nickel dermatitis and nickel cancer. Recent advancements in the understanding of the dual aspects of nickel as beneficial and a carcinogen are the key subject of this article.

Received 18th January 2022
Accepted 15th March 2022

DOI: 10.1039/d2ra00378c

rsc.li/rsc-advances

1. Introduction

An imbalance in the relative abundance of a few metals in the ecosystem can transform those elements into potential threats to its flora and fauna.[1,2] We have many works of literature about the toxicity of different metals; especially heavy metals (high-density elements) which can cause toxicity even at a lower concentration, making them one of the most significant environmental pollutants. Unlike the heavy metals, there are also some potential 'light metal' toxicants, which become a serious threat to the environment and eco-systems when exposed at elevated levels. Ni is one such metal. Ni and nickel-containing compounds are naturally distributed on the Earth's crust, ranking as the 24th most abundant element, and are constantly released into the atmosphere through various natural phenomena at modest levels.[3] It is a recognized essential element for several important biological processes like the

[a]Department of Chemistry, The University of Burdwan, Burdwan-713104, WB, India. E-mail: b_saha31@rediffmail.com; bsaha@chem.buruniv.ac.in; Fax: +91-342-2530452; Tel: +919476341691; +91-342-2533913

[b]Department of Chemistry, Mahendra Morang Adarsh Multiple Campus, Tribhuvan University, Biratnagar, Nepal. E-mail: bkajaya@yahoo.com; ajaya.bhattarai@mmamc.tu.edu.np

[c]Chemical Sciences Laboratory, Government General Degree College, Singur, Hooghly 712409, WB, India. E-mail: mmondal1208@gmail.com; Tel: +919475337890; +91-33-2630-0126

Wasefa Begum was born in Burdwan, India. She pursued her M.Sc. from Presidency University, Kolkata, India and is currently working as a JRF at The department of chemistry, Burdwan University, WB, India.

Summi Rai was born in Bhojpur, Nepal. She is currently an M.Sc. student of Mahendra Morang Adarsh Multiple Campus, Tribhuvan University, Biratnagar, Nepal. She has published some international peer reviewed scientific articles on Surfactant chemistry.

Chemistry Africa (2022) 5:459–480
https://doi.org/10.1007/s42250-022-00345-0

REVIEW

Comprehensive Review on Applications of Surfactants in Vaccine Formulation, Therapeutic and Cosmetic Pharmacy and Prevention of Pulmonary Failure due to COVID-19

Bidisha Das[1] · Biplab Kumar[1] · Wasefa Begum[1] · Ajaya Bhattarai[2] · Monohar Hossain Mondal[3] · Bidyut Saha[1]

Received: 19 January 2022 / Accepted: 8 March 2022 / Published online: 21 March 2022

Abstract
Our world is under serious threat of environmental degradation, climate change and in association with this the out breaks of diseases as pandemics. The devastating impact of the very recent COVID-19, The sharp increase in cases of Cancer, Pulmonary failure, Heart health has triggered questions for the sustainable development of pharmaceutical and medical sciences. In the search of inclusive and effective strategies to meet today's demand, improvised methodologies and alternative green chemical, bio-based precursors are being introduced by scientists around the globe. In this extensive review we have presented the potentiality and Realtime applications of both synthetic and bio-based surfactants in bio-medical and pharmaceutical fields. For their excellent unique amphoteric nature and ability to solubilise in both organic and inorganic drugs, surfactants are one of the most potential candidates for bio-medicinal fields such as dermatology, drug delivery, anticancer treatment, surfactant therapy, vaccine formulation, personal hygiene care and many more. The self-assembly property of surfactants is a very powerful function for drug delivery systems that increases the bio-availability of the poorly aqueous soluble pharmaceutical products by influencing their solubility. Over the decades many researchers have reported the antimicrobial, anti-adhesive, antibiofilm, anti-inflammatory, antioxidant activities of surfactants regarding its utility in medicinal purposes. In some reports surfactants are found to have spermicidal and laxative activity too. This comprehensive report is targeted to enlighten the versatile applications of Surfactants in drug delivery, vaccine formulation, Cancer Treatment, Therapeutic and cosmetic Pharmaceutical Sciences and prevention of pulmonary failure due to COVID-19.

Keywords Surfactant · COVID-19 · Pulmonary failure · Vaccine formulation · Drug delivery · Anti-cancer

1 Introduction

The most dangerous global threats against modern science are the fighting against climate change, environmental degradation, ecological downfall and in association with all these the degradation of human health, epidemics and pandemics like most recent COVID-19. Making remedies for the sustainable improvement of both human and environment health are the master tasks for scientists around the globe. In connection to this, environmental scientists are working on invention, discovery and development of sustainable green methodologies to protect environment from further degradation; where as in the field of bio-chemistry and pharmaceutical sciences, the challenge is not limited only in the identification of diseases and formulation of drugs but also characterising the drug's bio-activity, delivery and its potential future effect in human health. Inclusive strategies are thus required that might play pivotal role for the sustainable development of the environment, eradicate externalities, associated climate downfalls to inhibit the outbreak of epidemics and pandemics. A pure, non-contaminated and peaceful environment is the utmost need for good health of every living being on planet earth. In this

✉ Monohar Hossain Mondal
mmondal1208@gmail.com

✉ Bidyut Saha
b_saha31@rediffmail.com; bsaha@chem.buruniv.ac.in

1 Homogeneous Catalysis Laboratory, Department of Chemistry, The University of Burdwan, Burdwan 713104, WB, India

2 Department of Chemistry, M.M.A.M.C., Tribhuvan University, Biratnagar 56613, Nepal

3 Chemical Sciences Laboratory, Government General Degree College, Singur, Hooghly 712409, WB, India

RSC Advances

REVIEW

View Article Online
View Journal | View Issue

Cite this: RSC Adv., 2022, 12, 23973

Diverse utilization of surfactants in coal-floatation for the sustainable development of clean coal production and environmental safety: a review

Biplab Kumar,[a] Bidisha Das,[a] Amit Garain,[b] Summi Rai,[c] Wasefa Begum,[a] Md. Inamuddin,[d] Monohar Hossain Mondal,*[b] Ajaya Bhattarai*[c] and Bidyut Saha*[a]

The rapidly increasing modern industrial world demands a huge uninterrupted energy supply, where high-quality coal (HQC) is one of the major sources of the required energy. In this regard, a gigantic amount of solid waste including ash and toxic chemicals, such as heavy metals, nitrate and sulphur, gases including NOx and SOx are emitted during the direct incineration process of low-rank coal. About 10 Gt of CO_2 and about one-fifth of total greenhouse gases in the world are emitted each year due to coal combustion in power plants, making it the single largest cause of climate change. The UN proposed that OECD countries stop producing electricity from coal by 2030 and the rest of the world by 2040. Herein, we discuss the development of modern technologies that can convert low-quality coal (LQC) into high-quality coal (HQC) to minimize the impact of fossil fuel burn, climate change, premature death of animals and all other related environmental hazards. Amongst the many established technologies, flotation pre-treatment is the most common and effective method used worldwide due to its lower energy input than other methods. In this review, we attempt to present an up-to-date understanding of the applications and utilities of surfactants in coal floating. We also demonstrate the possible modernization of this surfactant chemistry and its prospects.

Received 6th May 2022
Accepted 9th August 2022

DOI: 10.1039/d2ra02861a

rsc.li/rsc-advances

1. Introduction

In coal-based thermal power stations, the most important input is good-quality coal to generate electricity. Worldwide, a total of about 8500 coal power stations with over 2000 gigawatt (GW) capacity are producing one-third of the world's total consumed electricity.[1] Coal is a combustible black or dark brown sedimentary organic rock, which consists of more than 50% weight carbonaceous material. Due to earthquakes and other natural

[a]Department of Chemistry, The University of Burdwan, Burdwan-713104, WB, India. E-mail: b_saha31@rediffmail.com; bsaha@chem.buruniv.ac.in; Fax: +91-342-2530452; Tel: +919476341691; +91-342-2533913

[b]Chemical Sciences Laboratory, Government General Degree College, Singur, Hooghly-712409, WB, India. E-mail: mmondal1208@gmail.com; Tel: +919475337890; +91-33-2630-0126

[c]Department of Chemistry, M.M.A.M.C., Tribhuvan University, Biratnagar 56613, Nepal. E-mail: ajaya.bhattarai@mmamc.tu.edu.np

[d]Department of Applied Chemistry, Aligarh Muslim University, Aligarh-202002, India

Biplab Kumar was born in West Bengal, India. He is pursuing his MSc from The University of Burdwan, WB, India. He is also a project student in the Bioremediation Laboratory under the supervision of Prof. Bidyut Saha.

Bidisha Das was born in West Bengal, India. She is pursuing her MSc from The University of Burdwan, WB, India. She is also a project student in the Bioremediation Laboratory under the supervision of Prof. Bidyut Saha.

B978-0-12-824283-4.00002-2, 00002

CHAPTER

c0010 Application of biosurfactant in the production of beverages

4

Monohar Hossain Mondal[a], Wasefa Begum[b], Ajaya Bhattarai[c], Dileep Kumar[d], Bula Singh[e], and Bidyut Saha[b]

[a]Chemical Sciences Laboratory, Government General Degree College, Hooghly, West Bengal, India [b]Homogeneous Catalysis Laboratory, Department of Chemistry, The University of Burdwan, Burdwan, West Bengal, India [c]Department of Chemistry, M.M.A.M.C., Tribhuvan University, Biratnagar, Nepal [d]Division of Computational Physics, Institute for Computational Science, Ton Duc Thang University, Ho Chi Minh City, Vietnam [e]Department of Chemistry, Siksha-Bhavan, Institute of Science, Visva-Bharti, Santiniketan, West Bengal, India

s0010 1 Introduction

p0015 Beverages (drinks) are liquids purposely formulated for human consumption. The basic functionality of beverages is to make up the thirst and electrolytic balance in the human body. From ancient times, beverages played important roles in different cultures and ethnic groups. The importance of beverages is associated with the dehydration of the human body, which is associated with the craving for fluids called thirst. The hypothalamus of the brain system regulates the thirst in response to the subtle changes in the body's electrolytic levels. The imbalance of electrolytes creates dysfunction of blood circulation in the body system (thus creating oxygen crisis), which may have fatal effects. To maintain a perfect balance of fluid and electrolytes, beverages have profound applications [1,2]. The beverage is an inclusive term for soft drinks, juices, milk derivatives, alcohols, beers, and warm beverages such as coffee, tea, hot chocolate, caffeinated drinks, etc. In modern times, various other types of beverages are also produced for purposes such as immunization, personal care, partying, and social celebrations. Whether formulated for relaxing or nourishing, indulging or energizing, beverages satisfy the desires of the customer with an ever-expanding menu of choices. With the increase in the array of choices for beverages, nuanced new needs are emerging. Consumers around the globe are looking for drinks that are more sophisticated, more natural, and authentic. The definition of new-generation beverage demands more bio-oriented and less synthetic foods for consumption, which includes lowering of addition of sugars, synthetic flavors, and chemicals. The demand for add-on benefits such as promotion of health, fitness,

Applications of Next Generation Biosurfactants in the Food Sector. https://doi.org/10.1016/B978-0-12-824283-4.00002-2

Inamuddin, 978-0-12-824283-4

Memorandum of Understanding

This Memorandum of Understanding (hereinafter called the MOU) is signed on the 10 th Day of May,2018 between Prof. Debasish Majumder, Professor H, Saha Institute of Nuclear Physics and Dr. Debabrata Adak, Assistant Professor of Physics, Government General Degree College, Singur about Research Collaborations in the field of Astrophysics and Cosmology.

Cluases of MOU

1). Both the signing parties will follow Research ethics, share ideas and will not show any conflict of interest while publishing any documents or research articles.

2). The parties will share their resources if any whenever required for this collaborative research.

Time period of Collaboration

This collaborating MOU will remain in vogue until one of the signing party wishes to withdraw himself from the MOU

Signed:

1). First Party:

Prof. Debasish Majumdar Debasish Majumdar

Professor
Saha Institute of Nuclear Physics
1/AF, Bidhan Nagar, Kolkata-700064

2). Second Party:

Dr. Debabrata Adak

Assistant Professor
Department of Physics
Government General Degree College
Singur, Hooghly, West Bengal-712409
Govt. of West Bengal

Functionality of the MOU

Within the purview of the MOU signed between Prof Debasish Majumdar, Professor H, Saha Institute of Nuclear Physics and Dr. Debabrata Adak, Assistant Professor of Physics, Government General Degree College Singur, the following outcomes were obtained:

1) One(01) Research Publication in International Journal and one (01) book chapter by International publication.

Signed:

Dated the 25th June, 2022

1) Prof. Debasish Majumdar Debasish Majumdar

Professor
Saha Institute of Nuclear Physics
1/AF, Bidhan Nagar, Kolkata-700064

2). Dr. Debabrata Adak

Assistant Professor
Department of Physics
Government General Degree College
Singur, Hooghly, West Bengal-712409
Govt. of West Bengal

Eur. Phys. J. C (2020) 80:593
https://doi.org/10.1140/epjc/s10052-020-8165-6

THE EUROPEAN PHYSICAL JOURNAL C

Regular Article - Theoretical Physics

Evolution of dark energy perturbations for Slotheon field and power spectrum

Upala Mukhopadhyay[1,a], **Debasish Majumdar**[1], **Debabrata Adak**[2]

[1] Astroparticle Physics and Cosmology Division, Saha Institute of Nuclear Physics, HBNI, 1/AF Bidhannagar, Kolkata 700064, India
[2] Department of Physics, Government General Degree College, Singur, Hooghly, West Bengal 712409, India

Received: 20 January 2020 / Accepted: 16 June 2020 / Published online: 30 June 2020

Abstract Within the framework of modified gravity model namely Slotheon model, inspired by the theory of extra dimensions, we explore the behaviour of Dark Energy and the perturbations thereof. The Dark Energy and matter perturbations equations are then derived and solved numerically by defining certain dimensionless variables and properly chosen initial conditions. The results are compared with those for standard quintessence model and ΛCDM model. The matter power spectrum is obtained and also compared with that for ΛCDM model. It appears that Dark Energy in Slotheon model is more akin to that for ΛCDM model than the standard quintessence model.

1 Introduction

In modern cosmology one of the most challenging problems is to explain the late time acceleration of the Universe. The distance measurements of Supernova Type Ia (standard candle) observations [1,2] revealed in 1998 that the expansion of the Universe is accelerating. Since then several other observations such as Cosmic Microwave Background Radiation observations (CMBR) [3–7], baryon acoustic oscillations measurements in galaxy power spectrum [8,9], large scale structure studies [10–12] have also indicated this phenomenon of late time acceleration of the Universe. The general consensus is that a mysterious component called Dark Energy with negative pressure (opposite to gravity) is causing the late time acceleration of the Universe. The CMBR anisotropy measurements suggest that the Dark Energy accounts for about 68.5% of the mass energy content of the present Universe.

As mentioned, the pressure acts opposite to that of gravity so as to accelerate the Universe in opposition to the tendency of an eventual gravitational collapse due to the mass present in the Universe. Several theoretical models have since been proposed for explaining the origin and nature of the mysterious Dark Energy and the consequent late time acceleration. There are attempts to interpret this Dark Energy by a cosmological constant Λ introduced in the Einstein's equations and the Friedmann equations that follows for FRW cosmology [13–18] with Einstein equations. However from the point of view of particle physics the cosmological constant naturally arises as an energy density of the vacuum, but in such scenario one has to make a fine tuning of the theoretical result of order 10^{121} [13,19]. Cosmological constant Λ is also associated with another theoretical problem, namely the cosmic coincidence problem [20]. The quintessence Dark Energy [21] is generally realized by considering a scalar field ϕ in a potential $V(\phi)$ [22] and as time progresses ϕ changes very slowly (slow roll). Various scalar field Dark Energy models have been studied in detail in literature [23–82]. Other attempts to explain this late time acceleration includes modification of Einstein's gravity in the large scale in the framework of theories of extra dimensions [83–87]. There are various proposals in the literature of higher dimensional models [88–93] to explain recent cosmic acceleration.

The Dark Energy and the inhomogeneities in the Dark Energy field are addressed by studying the Dark Energy perturbations [94,95]. This is related to the perturbations of space time [96–98] as also the perturbations of the scalar field that may be considered to account for the Dark Energy. The study of cosmological perturbations is also important because the matter and other perturbations that are derived from a proposed theory have direct consequences in accounting for the matter power spectrum.

In the present work we investigate the late time acceleration by a scalar field namely Slotheon [99–101] field inspired by extra dimensional models. A Slotheon field arises out of the Dvali, Gabadadze and Porrati (DGP) [102] model related to brane world. The mechanism of the DGP model is such that gravity can be localised in a 4-dimensional brane and at

[a] e-mail: upala.mukhopadhyay@saha.ac.in (corresponding author)

Chapter 131
Dark Energy Perturbation and Power Spectrum in Slotheon Model

Upala Mukhopadhyay, Debasish Majumdar, and Debabrata Adak

Abstract We explore the perturbationsn in Dark Energy by taking the Slotheon field model. The Slotheon field model follows from the extra-dimensional DGP (Dvali, Gabadadze, and Porrati) model and based on the Galileon transformation in curved space time. In this model a scalar field π in DGP theory is subjected to a shift symmetry in such a way that the final theory is invariant under this shift symmetry in curved space time. We consider that the accelerated expansion and Dark Energy are driven by the scalar field π with a potential $V(\pi)$. Then we explore the Dark Energy perturbations within the framework of this Slotheon model. Using these perturbations we compute the matter power spectrum.

131.1 Introduction

In this work we consider a scalar field model inspired by a model in theories of extra dimensions as an alternative way to explain the late time acceleration of the universe. At the limit when $M_{\rm pl} \to \infty$ and $r_c \to \infty$ where $M_{\rm pl}$ denotes reduced Planck mass and r_c is the cross over scale for transition from 4d to 5d, the Dvali Gabadadze Poratti (DGP) [1] model (an extra-dimensional model) in Minkowski spacetime can be described by a scalar field [2] which obey the Galileon shift symmetry $\pi \to \pi + a + b_\mu x^\mu$. A suitable scalar field π which respects this symmetry when extended

U. Mukhopadhyay (✉) · D. Majumdar
Astroparticle Physics and Cosmology Division, Saha Institute of Nuclear Physics, HBNI, 1/AF Bidhannagar, Kolkata 700064, India
e-mail: upala.mukhopadhyay@saha.ac.in

D. Majumdar
e-mail: debasish.majumdar@saha.ac.in

D. Adak
Department of Physics, Government General Degree College, Singur Hooghly, West Bengal 712409, India
e-mail: debabrata.adak.sinp@gmail.com

P. K. Behera et al. (eds.), *XXIII DAE High Energy Physics Symposium*,
Springer Proceedings in Physics 261,
https://doi.org/10.1007/978-981-33-4408-2_131

MOU between

Dr. Piyali Bhar,
Assistant Professor in Mathematics,
Govt. General Degree College, Singur
Hooghly: 712409

And

Megan Govender,
Professor of Mathematics,
Faculty of Applied Sciences,
Durban University of Technology, Durban, South Africa

MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding (hereinafter called the MOU) is signed on the 15 th Day of May, 2019 between **Dr. Piyali Bhar**, Assistant Professor, Govt. General Degree College, Singur and **Professor** Megan Govender, Department of Mathematics, Faculty of Applied Sciences, Durban University of Technology, Durban, South Africa about Research Collaborations in the field of Astrophysics..

Clauses of MOU

1). Both the signing parties will follow Research ethics, share ideas, co-operate in laboratory based studies and will not show any conflict of interest while publishing any documents or research articles.
2). Both the parties will utilise Research Grants whatsoever from any source for the fulfilment of that project.
3) Both the parties will jointly supervise Research Fellow students for his/her research degrees from any Universities/ Colleges.

Time period of Collaboration

This collaborating MOU will remain in vogue until one of the signing party wishes to withdraw himself from the MOU

Signed:

1). First Party:

Piyali Bhar

Dr. Piyali Bhar

Assistant Professor
WBES
Govt. Gen. Degree College
Singur, Hooghly

2). Second Party:

Professor Megan Govender

DEPARTMENT OF MATHEMATICS
DURBAN UNIVERSITY OF TECHNOLOGY
PO BOX 1334 — S3 Room 3304
DURBAN — STEVE BIKO CAMPUS
4000 — 4001 DURBAN

Functionality of the MOU

Within the purview of the MOU signed between Dr.Piyali Bhar, Assistant Professor, Govt. General Degree College, Singur and **Professor** Megan Govender, Department of Mathematics, Faculty of Applied Sciences, Durban University of Technology, Durban, South Africa

The following outcomes were obtained:

One Research Publication in International Journal has been published during 2020-2022.

Pramit Rej, **Piyali Bhar** and Megan Govender : "Charged compact star in f (R, T) gravity in Tolman–Kuchowicz spacetime ", *Eur. Phys. J. C* 81, 316 (2021)

[WoS & SCOPUS indexed, UGC care Group II listed]

Impact Factor : 4.991

Signed:
Dated the 26 th June, 2022

Piyali Bhar

1) Dr. Piyali Bhar

Assistant Professor
WBES
Govt. Gen. Degree College
Singur, Hooghly

2). Professor Megan Govender

DEPARTMENT OF MATHEMATICS
DURBAN UNIVERSITY OF TECHNOLOGY
PO BOX 1334
DURBAN
4000

53 Room 3304
STEVE BIKO CAMPUS
4001 DURBAN

Eur. Phys. J. C (2021) 81:316
https://doi.org/10.1140/epjc/s10052-021-09127-3

THE EUROPEAN PHYSICAL JOURNAL C

Regular Article - Theoretical Physics

Charged compact star in $f(R, T)$ gravity in Tolman–Kuchowicz spacetime

Pramit Rej[1,a], **Piyali Bhar**[2,b], **Megan Govender**[3,c]

[1] Department of Mathematics, Sarat Centenary College, Dhaniakhali, Hooghly, West Bengal 712 302, India
[2] Department of Mathematics, Government General Degree College, Singur, Hooghly, West Bengal 712 409, India
[3] Department of Mathematics, Faculty of Applied Sciences, Durban University of Technology, Durban, South Africa

Received: 4 March 2021 / Accepted: 6 April 2021

Abstract In this current study, our main focus is on modeling the specific charged compact star SAX J 1808.4-3658 (M = 0.88 $M_{\odot}$, R = 8.9 km) within the framework of $f(R, T)$ modified gravity theory using the metric potentials proposed by Tolman–Kuchowicz (Tolman in Phys Rev 55:364, 1939; Kuchowicz in Acta Phys Pol 33:541, 1968) and the interior spacetime is matched to the exterior Reissner–Nordström line element at the surface of the star. Tolman–Kuchowicz metric potentials provide a singularity-free solution which satisfies the stability criteria. Here we have used the simplified phenomenological MIT bag model equation of state (EoS) to solve the Einstein–Maxwell field equations where the density profile (ρ) is related to the radial pressure (p_r) as $p_r(r) = (\rho - 4B_g)/3$. Furthermore, to derive the values of the unknown constants a, b, B, C and the bag constant B_g, we match our interior spacetime to the exterior Reissner–Nordström line element at the surface of stellar system. In addition, to check the physical validity and stability of our suggested model we evaluate some important properties, such as effective energy density, effective pressures, radial and transverse sound velocities, relativistic adiabatic index, all energy conditions, compactness factor and surface redshift. It is depicted from our current study that all our derived results lie within the physically accepted regime which shows the viability of our present model in the context of $f(R, T)$ modified gravity.

1 Introduction

Einstein's General Relativity (GR) has continued to withstand the test of time in its predictions of physical phenomena within the realms of astrophysics and cosmology. From the classical predictions of the precession of Mercury's orbit and the deflection of starlight by a massive gravitating body to present day detection of gravitational waves and observations of black holes GR has triumphed. Early attempts seeking solutions of the Einstein field equations which describe stellar objects were crude and for most part unrealistic. The first exact solution of the Einstein field equations describing a self-gravitating sphere was obtained by Schwarzschild. The so-called interior Schwarzschild solution which described a constant density sphere suffered from various pathologies, the most notable being that the propagation speed for any signals within the fluid sphere was noncausal [1]. A survey of exact solutions appearing in the literature describing stellar objects by Delgaty and Lake [2] revealed that only a small subset of solutions meet the rigorous tests for physical viability, regularity and stability of fluid spheres.

The search for more realistic stellar models within GR required researchers to connect the macroscopic properties of stars determined through observations to the microphysics. A new era of stellar modeling was born, which went beyond the mathematical excursion of the Einstein field equations where ad hoc assumptions were made just to generate a toy model. Standard approaches which included assumptions on the metric function, density profiles, pressure profiles, anisotropy parameter and even the matter content which allowed for the system of equations to be integrated gave way to well-motivated techniques intrinsically connected to physics which include an equation of state (EoS), mass profiles linked to surface redshift and compactness of typical stellar structures. The linear EoS which links the radial pressure to the energy density has been generalized to include the microphysics (at least on a phenomenological level) via the so-called MIT bag model. The departure from pressure isotropy makes the modeling of stellar objects mathematically tractable. Imposing a barotropic EoS of the form $p_r =$

[a] e-mail: pramitrej@gmail.com (corresponding author)
[b] e-mail: piyalibhar90@gmail.com
[c] e-mail: megandhreng@dut.ac.za

Published online: 13 April 2021

MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding (hereinafter called the MOU) is signed on the **20th Day of May, 2019** between **Dr. SANTANU CHAKRABARTI**, Principal, Govt. General Degree College, Singur and **Dr. SAYAK GANGULI**, Assistant Professor of Biotechnology, St. Xavier's College, Kolkata about **Research Collaborations** in the field of Bioinformatics and microbiology of *Shigella*, a bacteria causing dreadful enteric diseases.

Clauses of MOU

1). Both the signing parties will follow Research ethics, share ideas, co-operate in laboratory based studies and will not show any conflict of interest while publishing any documents or research articles.
2). Both the parties will utilise Research Grants whatsoever from any source for the fulfilment of that project.
3). Both the parties will jointly supervise Research Fellow students for his/her research degrees from any Universities/ Colleges.

Time period of Collaboration

This collaborating MOU will remain in vogue until one of the signing party wishes to withdraw himself from the MOU

Signed:

1). First Party:

Dr. Santanu Chakrabarti

Dr. SANTANU CHAKRABARTI
WBSES
PRINCIPAL
GOVT. GENERAL DEGREE COLLEGE, SINGUR

2). Second Party:

Dr. Sayak Ganguli

Sayak Ganguli Ph.D.
Assistant Professor
Department of Biotechnology
St. Xavier's College, (Autonomous)
30, Mother Teresa Sarani (Park Street)
Kolkata - 700016

Functionality of the MOU

Within the purview of the MOU signed between **Dr. Santanu Chakrabarti**, Principal, Govt. General Degree College Singur and **Dr. Sayak Ganguli**, Assistant Professor of Biotechnology, St. Xavier's College, Kolkata the following outcomes were obtained:

1) One **Research Project** funded by **West Bengal Science & Technology**, Govt of West Bengal is being pursued. Submission of final report is expected anytime in 2023.

2) Two(02) **Research Publications** in International Journal and two(02) in National reputed journals have been published during 2020-2022 where a Research Fellow, Ms. Sarmistha Mukhopadhyay is also a co-author.

3) Ms. Sarmistha Mukhopadhyay has been registered for her **PhD** degree in St Xavier's College where both Dr. Sayak Ganguli is the **Supervisor** and Dr. Santanu Chakrabarti is the **co- supervisor** in 2022.

4) They have presented their research works in many symposia jointly.

Signed:

Dated the 25th June, 2022

Dr. Santanu Chakrabarti

Dr. SANTANU CHAKRABARTI
WBSES
PRINCIPAL
GOVT. GENERAL DEGREE COLLEGE, SINGUR

Dr. Sayak Ganguli

Sayak Ganguli **Ph.D.**
Assistant **Professor**
Department **of Biotechnology**
St. Xavier's **College, (Autonomous)**
30, Mother **Teresa Sarani (Park Street)**
Kolkata - 700016.

ST. XAVIER'S COLLEGE (AUTONOMOUS)

UNIVERSITY OF CALCUTTA

Ph.D Registration

Ph.D Roll No.	:	Ph.D./21/BMBT/01
Department of	:	Biotechnology
Name of the Registered Candidate	:	Sarmishta Mukhopadhyay
Date of Enrolment	:	05.01.2021
Date of Ph.D Registration	:	15.09.2022
Topic of Research	:	GENOMICS GUIDED TARGET IDENTIFICATION AND VIRTUAL SCREENING OF NATURAL COMPOUND LIBRARY TO PROPOSE INHIBITORS AGAINST *SHIGELLA* SPP.

This registration remains valid for five years from the date of registration mentioned above.

Principal Supervisor	:	Dr. Sayak Ganguli
Designation	:	Assistant Professor, St. Xavier's College
Joint Supervisor (2)	:	Dr. Santanu Chakrabarti
Designation	:	Principal, Govt. General Degree College, Singur
Signature of the candidate	:	Sarmishta Mukhopadhyay

Signature of the supervisor(s)

1. Sayak Ganguli

2.

Dr. SANTANU CHAKRABARTI
WBSES
PRINCIPAL
GOVT. GENERAL DEGREE COLLEGE, SINGUR

Samrat Roy
Signature of the Ph.D. Coordinator

Signature of the Principal

J. Environ. & Sociobiol. : 19(1) : 37-42, 2022 Print : ISSN : 0973-0834
Received : 22 April, 2022 / Reviewed & Accepted : 10 June, 2022 / Uploaded Online : October, 2022

INSIGHTS INTO THE STRUCTURE AND DYNAMICS OF *SHIGELLA* INVASION PROTEINS FOR USE AS POTENTIAL DRUG TARGETS

Sarmishta Mukhopadhyay[1] Santanu Chakrabarti[2] and Sayak Ganguli[1]*
[1] Department of Biotechnology, St. Xavier's College (Autonomous), Kolkata-700016, India
[2] Department of Zoology, Government General Degree College, Singur, West Bengal, India
*Corresponding author: sayakganguli@sxccal.edu

ABSTRACT

The Gram-negative bacteria, *Shigella* spp. has always been a pathogen of concern in the context of global burden of diarrheal diseases, with recent surveys taking the annual incidence of shigellosis to roughly 125 million cases worldwide. The scenario has been further worsened by the frequent reports on isolation of multi drug resistant (MDR) *Shigella* strains, showing resistance against potent antibiotics including the 3rd generation cephalosporins as well. With the recent years witnessing a growing interest in the discovery of novel drugs, this work has scrutinized the structural nitty-gritty of the predominant virulence factors in *Shigella*, viz. the invasion plasmid antigens IpaA, IpaB, IpaC and IpaD, that are evidenced to have multifaceted role in the pathogenesis cascade, to explore their potential as promising therapeutic targets. In this work we report the 3D models of the different invasion proteins using comparative modeling and a comprehensive structural evaluation protocol for evaluating their stability as drug targets. Our data suggest significant potential of these invasion proteins to serve as future drug targets, thus opening up the avenue for further investigations.

Key words: *Shigella, Invasion proteins, Structural analysis, Drug targets, In-silico.*

INTRODUCTION

Shigella species are Gram-negative enteric pathogens, routinely sequestered from patients with acute intestinal infections, often with extra intestinal manifestations.

Exploring the functions and interactions of undeciphered proteins from *Shigella flexneri*

Sarmishta Mukhopadhyay

Department of Biotechnology,
St. Xavier's College (Autonomous),
Kolkata – 700016, India
Email: sarmi.rumi@gmail.com

Sayak Ganguli*

Department of Biotechnology,
St. Xavier's College (Autonomous),
Kolkata – 700016, India
Email: sayakganguli@sxccal.edu

Santanu Chakrabarti*

Department of Zoology,
Government General Degree College,
Singur, West Bengal – 712409, India
Email: scwbes@gmail.com
*Corresponding authors

Abstract: Multiple serotypes of *Shigella* and surfacing of antimicrobial resistant strains pose a serious threat in treating shigellosis. A significant proportion of the *Shigella flexneri* genome (18%) codes for Hypothetical Proteins (HPs), which may be involved in key cellular and signalling pathways, that play decisive role in pathogen survival and dissemination. This work employs a computational workflow to determine the family, domain, sub-cellular localisation and possible interacting partners of these unannotated proteins. The investigation could successfully assign functions to 432 HPs from *Shigella flexneri* genome and classified them into 20 different groups in accordance with their functions. Enzymes being the most prevalent group, were further categorised into several classes depending on the reaction it catalyses. This work should serve as a reference pipeline for annotation of other HPs from pathogenic organisms and detailed experimental investigations of these annotated proteins should help us to identify novel therapeutic targets for future drug discovery.

Keywords: *Shigella sp*; shigellosis; hypothetical proteins; in-silico; therapeutic targets.

Reference to this paper should be made as follows: Mukhopadhyay, S., Ganguli, S. and Chakrabarti, S. (2022) 'Exploring the functions and interactions of undeciphered proteins from *Shigella flexneri*', *Int. J. Computational Biology and Drug Design*, Vol. 15, No. 1, pp.60–75.

J. Environ. & Sociobiol. : 17(1) : 65-78, 2020 Print : ISSN : 0973-0834
Received : 03 March, 2020 / Reviewed & Accepted : 10 June, 2020 / Uploaded Online : August, 2020

FUNCTIONAL ANNOTATION OF PATHOGENESIS PROTEINS IN *SHIGELLA FLEXNERI* USING COMPARATIVE GENOMICS

Sarmishta Mukhopadhyay[1], Sayak Ganguli[2] and Santanu Chakrabarti[1]*
[1]Department of Zoology, Government General Degree College, Singur, West Bengal
[2]Department of Biotechnology, St. Xavier's College, Kolkata- 700016.
***Corresponding author**: Santanu Chakrabarti, Email: scwbes@gmail.com

ABSTRACT

The Gram-negative bacteria, *Shigella* species, is a predominant diarrheal pathogen and itself accounts for 15% of the diarrheal episodes occurring globally. *Shigella* enters the human body through ingestion of contaminated food and water and on reaching the intestine, dismantles the epithelial barrier, generating symptoms varying from mild to severe bloody diarrhea. Widespread diversity of *Shigella* species and the emergence of multi-drug resistant strains in recent years has made it extremely enigmatic to design a successful drug to combat shigellosis. This work focusses on comparative genomics methods to identify and annotate hypothetical proteins from the *Shigella flexneri* genome in quest of identifying novel druggable targets.

Key words: *Shigellosis, hypothetical proteins, comparative genomics, drug targets.*

INTRODUCTION

The genome of *Shigella flexneri* includes a significant proportion (18%) of encoded proteins whose functions are yet to be deciphered (Jin *et al*., 2002). The functional characterization of these hypothetical proteins (HPs) will provide us with important insights into their cellular functions and involvement in metabolic pathways. Most of these proteins are thought to play a pivotal role in the cell and their annotation can lead to the discovery of novel drug targets(Chakrabarti and Ganguli, 2011). Bioinformatics has equipped us with a vast array of tools that facilitate the characterization of these non-elucidated proteins using in *in-silico* approaches. The purpose of this work is to assign occupation to these HPs that may unveil potential therapeutic targets for future drug discovery.

Molecular Science

AIMS Molecular Science, 7(2): 99–121.
DOI: 10.3934/molsci.2020007
Received: 02 April 2020
Accepted: 11 May 2020
Published: 13 May 2020

http://www.aimspress.com/journal/Molecular

Review

Shigella pathogenesis: molecular and computational insights

Sarmishta Mukhopadhyay[1], Sayak Ganguli[2] and Santanu Chakrabarti[1,*]

[1] Department of Zoology, Government General Degree College, Singur, West Bengal, India
[2] Department of Biotechnology, St. Xavier's College (Autonomous), Kolkata-700016, India

* **Correspondence:** Email: scwbes@gmail.com; Tel: 8334031053.

Abstract: Shigellosis, characterized by inflammation and ulceration of the large intestine, is caused by infection with *Shigella* species. It is a major public health problem in developing countries where filthy sanitation practices and restricted access to clean water encourage the spread of the disease. Shigellosis is spread by means of fecal-oral route. It is one of the most common disorders specially affecting children in West Bengal, India. Disease from *Shigella* species accounts for 165 million cases of diarrhoea culminating in one million deaths annually worldwide. Severe dysentery is treated still with antibiotics, with limited success because of the continuous development of multi drug resistance by the bacteria. WHO has identified *Shigella* as a potential target pathogen against which new drugs need to be formulated and *in silico* approach has the potential to identify drug targets. Molecular modeling of *Shigella* invasion proteins using computational tools may divulge novel therapeutic targets that can be used for future pharmacological intervention. Detailed annotation of previously unknown Hypothetical Proteins using an *in-silico* pipeline can identify crucial proteins in pathogenesis cascade, which can be explored further as effective drug targets, which may eventually enable us to combat the menace of shigellosis.

Keywords: drug design; *in silico*; *Shigella* pathogenesis; Shigellosis; T3SS effectors

1. Introduction

Diarrheal diseases have always been a threat to growing human population all over the world, with increased incidence in developing countries like India, China, Bangladesh, etc. *Shigella* spp. is

MOU between

Dr. Piyali Bhar,
Assistant Professor in Mathematics,
Govt. General Degree College, Singur
Hooghly: 712409

And

Dr. Pradyumn Kumar Sahoo,
Professor of Mathematics,
Birla Institute of Technology & Science, Pilani
Hyderabad Campus,
Jawahar Nagar, Kapra Mandal,
Hyderabad-500078, INDIA

MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding (hereinafter called the MOU) is signed on the 20th Day of May, 2019 between **Dr. Piyali Bhar**, Assistant Professor in Mathematics, Govt. General Degree College, Singur and **Dr. Pradyumn Kumar Sahoo**, Professor of Mathematics, Birla Institute of Technology & Science, Pilani about Research Collaborations in the field of Astrophysics of wormhole in modified gravity.

Clauses of MOU

1). Both the signing parties will follow Research ethics, share ideas, co-operate in laboratory based studies and will not show any conflict of interest while publishing any documents or research articles.

2) Both the parties will jointly supervise Research Fellow students for his/her research degrees from any Universities/ Colleges.

Time period of Collaboration

This collaborating MOU will remain in vogue until one of the signing party wishes to withdraw himself from the MOU

Signed:

1). First Party:

Piyali Bhar

Dr. Piyali Bhar

Assistant Professor
WBES
Govt. Gen. Degree College
Singur, Hooghly

2). Second Party:

Dr. Pradyumn Kumar Sahoo

Prof. P. K. SAHOO
Professor
Department of Mathematics
BITS-Pilani, Hyderabad Campus,
Jawahar Nagar, Kapra Mandal,
Hyderabad-500078, INDIA.

Functionality of the MOU

Within the purview of the MOU signed between **Dr. Piyali Bhar**, Assistant Professor in Mathematics, Govt. General Degree College, Singur and **Dr. Pradyumn Kumar Sahoo**, Professor of Mathematics, Birla Institute of Technology & Science, Pilani

The following outcomes were obtained:

One Research Publications in International Journal have been published during 2020-2022.

Piyali Bhar, Pramit Rej and P. K. Sahoo: "Phantom energy-supported wormhole model in $f(R,T)$ gravity assuming conformal motion", *International Journal of Modern Physics D*, Vol. 31, No. 03, 2250016 (2022) **Impact factor: 2.547**

[WoS & SCOPUS indexed, UGC care Group II listed]

Signed:
Dated the 26th June, 2022

Piyali Bhar

1) Dr. Piyali Bhar

Assistant Professor
WBES
Govt. Gen. Degree College
Singur, Hooghly

2) **Dr. Pradyumn Kumar Sahoo**

Prof. P. K. SAHOO
Professor
Department of Mathematics
BITS-Pilani, Hyderabad Campus,
Jawahar Nagar, Kapra Mandal,
Hyderabad-500078, INDIA.

International Journal of Modern Physics D
Vol. 31, No. 3 (2022) 2250016 (20 pages)

DOI: 10.1142/S021827182250016X

World Scientific
www.worldscientific.com

Phantom energy-supported wormhole model in $f(R, T)$ gravity assuming conformal motion

Piyali Bhar*,§, Pramit Rej†,¶ and P. K. Sahoo‡,‖

*Department of Mathematics,
Government General Degree College,
Singur, Hooghly, West Bengal 712 409, India

†Department of Mathematics,
Sarat Centenary College,
Dhaniakhali, Hooghly, West Bengal 712 302, India

‡Department of Mathematics,
Birla Institute of Technology and Science-Pilani,
Hyderabad Campus, Hyderabad 500078, India
§piyalibhar90@gmail.com; piyalibhar@associates.iucaa.in
¶pramitrej@gmail.com
‖pksahoo@hyderabad.bits-pilani.ac.in

Received 12 September 2021
Revised 20 October 2021
Accepted 23 November 2021
Published 20 December 2021

In this article, we have discussed Morris and Thorne (MT) wormhole solutions in a modified theory of gravity that admits conformal motion. Here, we explore the wormhole solutions in $f(R, T)$ gravity, which is a function of the Ricci scalar (R) and the trace of the stress–energy tensor (T). To study wormhole geometries, we make assumption of spherical symmetric static spacetime and the existence of conformal Killing symmetry to get more acceptable astrophysical outcomes. To do this, we choose the expression of $f(R, T)$ as $f(R, T) = R + 2\gamma T$. Here, we employ the phantom energy EoS relating to radial pressure and density given by $p_r = \omega\rho$ with $\omega < -1$ to constrain our model. Following a discussion of wormhole geometry and behavior of shape function, the study moves on to the computation of proper radial distance, active mass function, the nature of total gravitational energy and a discussion on the violation of energy conditions. We have shown that the wormhole solutions exist for positive as well as negative values of the coupling constant γ. From our analysis, we see that no wormhole solution exists for $\gamma = -4\pi$, $-\pi(3 + \omega)$. All the physical parameters have been drawn by employing the values of γ as $\gamma = -0.3$, -0.2, -0.1, 0, 0.1 and 0.2, where $\gamma = 0$ corresponds to general relativity (GR) case. It is found that for our proposed model, a realistic wormhole solution satisfying all the properties can be obtained.

Keywords: Wormhole; phantom energy; exotic matter; modified gravity.

§Corresponding author.

MOU between

Dr. Piyali Bhar,
Assistant Professor in Mathematics,
Govt. General Degree College, Singur
Hooghly: 712409

And

Dr. Farook Rahaman,
Professor of Mathematics,
Jadavpur University, Kolkata
Kolkata: 700032

MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding (hereinafter called the MOU) is signed on the 24th Day of May, 2019 between Dr. Piyali Bhar, Assistant Professor in Mathematics, Govt. General Degree College, Singur and Dr. Farook Rahaman, Professor of Mathematics, Jadavpur University, Kolkata about Research Collaborations in the field of Astrophysics of Compact star model in General theory of Relativity and modified gravity.

Clauses of MOU

1) Both the signing parties will follow Research ethics, share ideas, co-operate in laboratory based studies and will not show any conflict of interest while publishing any documents or research articles.
2) Both the parties will jointly supervise Research Fellow students for his/her research degrees from any Universities/ Colleges.

Time period of Collaboration

This collaborating MOU will remain in vogue until one of the signing party wishes to withdraw himself from the MOU

Signed

1). First Party:

Piyali Bhar

Dr. Piyali Bhar

Assistant Professor
WBES
Govt. Gen. Degree College
Singur, Hooghly

2). Second Party:

Farook Rahaman

Dr. Farook Rahaman

DR. FAROOK RAHAMAN
Professor
Department of Mathematics
JADAVPUR UNIVERSITY
Kolkata-700032, W.B., INDIA

Functionality of the MOU

Within the purview of the MOU signed between Dr. Piyali Bhar, Assistant Professor in Mathematics, Govt. General Degree College, Singur and Dr. Farook Rahaman, Professor of Mathematics, Jadavpur University, Kolkata.

The following outcomes were obtained:

Two Research Publications in International Journal have been published during 2020-2022.

1. Ksh. Newton Singh, Shyam Das, **Piyali Bhar**, Monsur Rahaman and Farook Rahaman: "Color-flavor locked compact stars: An exact solution approach" *International Journal of Modern Physics A*, Vol. 36, No. 27, 2150192 (2021)
   Impact factor: 1.475
   [WoS & SCOPUS indexed, UGC care Group II listed]

2. Ksh Newton Singh, S K Maurya, **Piyali Bhar** and Farook Rahaman: "Anisotropic stars with a modified polytropic equation of state ", *Physica Scripta*. 95, 115301 (2020) **Impact factor: 3.081,**
   [WoS & SCOPUS indexed, UGC care Group II listed]

Signed
Dated the 25th June, 2022

Piyali Bhar

1) Dr. Piyali Bhar

Assistant Professor
WBES
Govt. Gen. Degree Co
Singur, Hooghly

Farook Rahaman

2). Dr. Farook Rahaman

DR. FAROOK RAHAMAN
Professor
Department of Mathematics
JADAVPUR UNIVERSITY
Kolkata-700032, W.B., INDIA

IOP Publishing Physica Scripta
Phys. Scr. 95 (2020) 115301 (16pp) https://doi.org/10.1088/1402-4896/abc03b

Anisotropic stars with a modified polytropic equation of state

Ksh Newton Singh[1,2], **S K Maurya**[3,*], **Piyali Bhar**[4] and **Farook Rahaman**[1]

[1] Department of Mathematics, Jadavpur University, Kolkata 700 032, West Bengal, India
[2] Department of Physics, National Defence Academy, Khadakwasla, Pune-411023, India
[3] Department of Mathematics and Physical Science, College of Arts and Science, University of Nizwa, Nizwa, Oman
[4] Department of Mathematics,Government General Degree College, Singur, Hooghly, West Bengal 712 409, India

E-mail: ntnphy@gmail.com, sunil@unizwa.edu.om, piyalibhar90@gmail.com and rahaman.associates@iucaa.ernet.in

Received 31 July 2020, revised 25 September 2020
Accepted for publication 12 October 2020
Published 21 October 2020

Abstract

In this article, we have presented the anisotropic stars by taking a modified polytropic equation of state ($p_r = k\,\rho^{1+1/n} - \alpha$, where k and α are constants) in the framework of the Korkina-Orlyanskii spacetime. In this study, we have discussed four different models as: (A) $n = 1$ (Bose–Einstein Condensate (BEC) neutron liquid), (B) $n = 2$, (C) $n = 3/2$ (Non-relativistic neutron gas, (D) $n = 3$ (Ultra relativistic Fermi-gas). Moreover, we have tested several physical properties for each model. To compare the stiffness of these four models, we have plotted the $M - R$ curves, $M - I$ curves and compression modulus. As per the $M - R$ curves, the equation of state can hold maximum mass when the polytropic index in 2 and minimum mass when $n = 1$ (BEC neutron liquid). Further, the ultra relativistic Fermi gas ($n = 3$) can also hold more M_{max} than its non-relativistic counter part ($n = 3/2$). These results are further supported by the compression modulus. Lastly, to show its physical validity we have fitted six well known compact stars in $M - R$ curve within their observational error bars.

Keywords: compact star, equation of state, general relativity

(Some figures may appear in colour only in the online journal)

1. Introduction

The polytropic equation of state (EoS) was successfully used by several astrophysicists in describing the physical properties of main sequence stars. This EoS was forwarded by Lane, Ritter, Kelvin, Emden, and Fowler. To describe a star under hydrostatic equilibrium, one needs to solve the Lane-Emden equation with the assumption of an EoS. With the assumption of polytropic EoS i.e. $p = k\rho^{\Gamma} = k\rho^{1+1/n}$, the Lane-Emden equation can be solve exactly only for $n = 0$, 1 and 5. For polytropic indices 0 and 1 the solutions has finite boundaries whereas for $n = 5$ the boundary is at infinity. Therefore, only the first two solutions can represent physical stars. It is also shown that $n > 5$ polytropes can't represent physical stars.

For the case of white dwarfs (WD), the pressure supporting the stars is due to degenerate electron gas. For non-relativistic electron gas the polytropic index is $3/2$ ($\Gamma = 5/3$) and for relativistic electron gas $n = 3$ ($\Gamma = 4/3$). Using the relativistic case, Chandraseskhar [1] first shown that the maximum mass of WD is independent of its central density and is equal to $1.46M_{\odot}$. If the mass of the WD is more than the Chandrasekhar limit by any physical process (either the initial mass is very massive or due to accretion) it will trigger a gravitational instability resulting into a collapse. Depend upon the initial mass or the rate of accretion the collapsing star may form a neutron star or a black hole. Both these compact objects acquired very high surface gravity and therefore incorporating general relativity is a must.

Oppenheimer and Volkoff [2] first used general relativity with the assumption that NSs are supported by degenerate

* Author to whom any correspondence should be addressed.

International Journal of Modern Physics A
Vol. 36, No. 27 (2021) 2150192 (14 pages)

DOI: 10.1142/S0217751X2150192X

Color-flavor locked compact stars: An exact solution approach

Ksh. Newton Singh*
Department of Physics, National Defence Academy, Khadakwasla, Pune, Maharashtra 411023, India
ntnphy@gmail.com

Shyam Das
Department of Physics, Malda College, Malda 732101, West Bengal, India
dasshyam321@gmail.com

Piyali Bhar
Department of Mathematics, Government General Degree College, Singur, Hooghly, West Bengal 712409, India
piyalibhar90@gmail.com

Monsur Rahaman and Farook Rahaman
Department of Mathematics, Jadavpur University, Kolkata 700032, West Bengal, India
mansur.rahman90@gmail.com
rahaman@iucaa.ernet.in

Received 28 April 2021
Revised 22 August 2021
Accepted 2 September 2021
Published 12 October 2021

We present an exact solution that could describe compact star composed of color-flavor locked (CFL) phase. Einstein's field equations were solved through CFL equation of state (EoS) along with a specific form of g_{rr} metric potential. Further, to explore a generalized solution we have also included pressure anisotropy. The solution is then analyzed by varying the color superconducting gap δ and its effects on the physical parameters. The stability of the solution through various criteria is also analyzed. To show the physical validity of the obtained solution we have generated the $M - R$ curve and fitted three well-known compact stars. This work shows that the anisotropy of the pressure at the interior increases with the color superconducting gap leading to decrease in adiabatic index closer to the critical limit. Further, the fluctuating range of mass due

*Corresponding author.

होमी भाभा विज्ञान शिक्षा केंद्र
HOMI BHABHA CENTRE FOR SCIENCE EDUCATION
टाटा मूलभूत अनुसंधान संस्थान
TATA INSTITUTE OF FUNDAMENTAL RESEARCH
भारत सरकार का नाभिकीय विज्ञान एवं गणित का राष्ट्रीय केंद्र एवं समविश्वविद्यालय
National Centre of the Government of India for Nuclear Science and Mathematics and a Deemed University
वी . एन . पुरव मार्ग, मानखुर्द, मुंबई 400 088
V. N. Purav Marg, Mankhurd, Mumbai 400 088.

दूरभाष / Telephone : 022-2507 2105/ 2117/ 2177
फैक्स / Fax : 022-2556 6803
वेवसाइट / Website : www.hbcse.tifr.res.in

Jan 16, 2023

To whom it may concern

Dr. Amrit Krishna Mitra from Government General Degree College, Singur, Hooghly has been a resource person for the Indian Chemistry Olympiad Program since February 2020.

The Indian Chemistry Olympiad is a National programme of Government of India conducted by Homi Bhabha Centre for Science Education (HBCSE, TIFR) that leads to the selection of the Indian team for the International Chemistry Olympiad every year. An important feature of the program are challenging theoretical and experimental problems that can help students of chemistry see the relevance of various concepts taught in the subject.

The resource persons play an important role in the program by bringing diversity in ideas and implementation to the program. Dr. Mitra has been helping with various aspects of the program for the last four years in the domain of Organic Chemistry.

We sincerely thank him for his contributions to the program in the past and look forward to his continued association.

Sincerely,

Ankush Gupta
Academic Coordinator
Indian National Chemistry Olympiad