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A Study on Bio-Concrete using by-Products of Ethanol (High Lignin Ash) Replacing Partially with Cement

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Chapter - 1

A Study on Bio-Concrete using by-Products of Ethanol (High Lignin Ash) Replacing Partially with Cement

Sreevidya Raman S and Shankar B.S

Abstract

Corn stover cellulose and hemicellulose has been utilized as a substrate for ethanol production using Saccharomyces cerevisiae. Lignocellulosic materials through a process of pre-treatment, hydrolysis and fermentation produces ethanol from a corn stover. With the cellulosic ethanol process, left over material which has lignin and some cellulose in it can be burn out to get the ash. Adding this high lignin ash to the cement, makes concrete strong and durable. Corn stover has the potential for use as a supplementary cementitious material (SCM) for concrete. On the pozzolanic reactivity of corn stover ash (CSA), the effects of distilled water and diluted acid pre-and post-treatments were investigated. The possible application of high lignin residue (HLR), a bioethanol by product, in the synthesis of SCM was also looked at. When utilised as a 20% replacement for cement in the system, pre-treatment CSA and high lignin residue ash (HLRA) improved the early reactivity of cement paste, however unpretreated CSA was discovered to significantly stifle the hydration reaction. From samples containing HLRA, the maximum compressive strength was attained.

Keywords: Corn stover, compressive strength ethanol, high lignin residue

Introduction

As a significant and crucial step towards reducing contemporary society's reliance on fossil fuels, the introduction of biofuels into the transportation sector, bioethanol has already been implemented as a petrol substitute in some nations [1-3]. From the perspective of sustainability, bioethanol should be created from secondary biomass derived mostly from lignocellulosic waste, with the benefits of both utilising the waste through resource recovery and avoiding the use of biomass that would otherwise be used as food for human consumption [4]. Around the world, there exist large amounts of lignocellulosic waste, particularly corn stover [2-5]. Corn is not only the largest agricultural

commodity in the world (1.06 £ 109 t/y of corn, 7.49 £ 108 t/y of wheat and 7.41 £ 108 t/y of rice) [6], Nevertheless, the stover component of corn's by-product is also important. Consequently, the manufacture of bioethanol from corn stover may be a crucial technique for the manufacturing of ethanol as a petrol substitute. As a typical lignocellulosic feedstock, maize stover contains lignin, cellulose and hemicellulose. Together, these three components form a complex polymer structure that prevents reaction media or enzymes from coming into intimate contact with cellulose, making maize stover difficult to convert into bioethanol [7]. Pre-treatment, which tries to disassemble the crystalline and polymeric structures before the hydrolysis, fermentation, and final purification steps, is therefore crucial. Many studies have been done recently on the pre-treatment of maize stover, including physical, chemical, biological and other procedures. While the later steps are technologically quite well understood [8-9]. Physical pre-treatment commonly entails milling, extrusion, and microwave irradiation; physicochemical pre-treatment refers to steam explosion, liquid hot water explosion, ammonia fibre explosion and supercritical CO_2 explosion; chemical pre-treatment frequently uses acid and alkaline materials and occasionally organic solvent or ionic liquid as reaction media; biological pre-treatment uses microorganisms like various types of fungi [10]. Although acid and hydrothermal technologies can also be used as hydrolysis processes, enzymatic hydrolysis now dominates the hydrolysis of carbohydrates. These technologies share the same goal of increasing ethanol production, but their approaches, operating parameters and yields fundamentally differ. Even within the same technology, operational circumstances, as well as sugar and ethanol yields, might change significantly. Microorganisms enjoy various fungus species. Furthermore, full-scale technologies are still in short supply and in the early stages of development [10, 11].

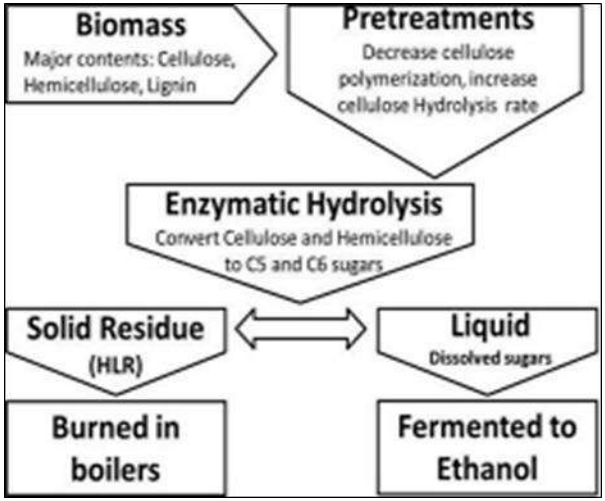

Fig 1: Bioethanol production process

Materials required

1) **For the extraction of high lignin ash, the materials and apparatus required are:** Corn stover, Sodium Hydroxide solution, Sulphuric acid, Glass beakers, Glass rod, Oven, Filter papers, Funnel, 250ml Conical flask.
2) **For concrete, materials required are:** Cement, Aggregates (Fine and Coarse), High lignin Ash, Water.

Methodology

a) Method of extraction of high lignin ash from corn stover are

1. Sample preparation

The corn stover is collected from and taken to a standard laboratory for analysis. The corn stover is cleaned, chopped and oven-dried at 60 °C for 48 hours at moisture content of 10 % dry basis. The oven dried corn stover is then milled between 10-25mm to 0.1-0.5mm particle. The milled corn stover is sieved to produce a uniform particle size between 0.180-0.250mm and kept in a sealed plastic jar at room temperature until required for treatment.

2. Alkaline pre-treatment of corn stover

Corn stover pre-treatment helps to increase accessibility to plant cell wall polysaccharides for carbohydrate-active enzymes to produce sugars for bioethanol fuels. Thus, 98grams of the milled corn stover was mixed with 800ml of distilled water containing 2grams of anhydrous NaOH crystals. This

resulted in a solid to liquid weight ratio of 1:8. The mixture is autoclaved at 121 ºC for 25 min filtered, the residue washed and oven dried at 65 ºC.

3. Hydrolysis

The alkaline pre-treated corn stover is hydrolysed with dilute sulphuric acid (H_2SO_4) and hydrochloric acid (HCl) at different concentrations of H_2SO_4 (i.e. 1, 2 and 4% H_2SO_4 in distilled water respectively). In order to break down the cellulose and hemicelluloses into simple sugar, 20mg of the pre-treated corn stover sample was maintained at solid to liquid ratio of 1:10, in 250 ml round bottom flask and refluxed. Samples (60ml each), were retained after 2, 4, and 6 hours of hydrolysis for subsequent fermentation experiments. After hydrolysis the liquid fraction of the hydrolysate samples was cooled, filtered, collected, and adjusted to pH 5 by adding concentrated sulphuric acid and 2N Sodium hydroxide, and the solutions prepared for fermentation.

4. Ash production

The biomass samples were heated to a predetermined temperature and held for a predetermined amount of time using a programmable electric muffle furnace. Each batch of corn stover ash (CSA) was generated by burning 200 g of dry corn stover. The biomass was held during burning in a stainless-steel cage with two wire mesh shelves. Below the cage, a stainless-steel pan was set up to catch any ash that managed to get through the mesh. By putting 100 gr of high lignin residue (HLR) on a stainless-steel pan and heating it in a furnace, high lignin residue ash (HLRA) was created. Samples were heated to 500 ºC for two hours (500/2) or 650 ºC for one hour (650/1). Finally, the ash was pulverised in a laboratory ball mill for an hour at 85 revolutions per minute (rpm). Ash samples are named as follows: kind of ash, pre-treatment, washing intervals, burning temperature, and holding period.

b) High lignin ash added to concrete

High lignin ash (biofuel by-product) is added to concrete replacing partially with cement in different percentages that is 10%,20% and 30% of high lignin and 90%, 80% and 70% of cement to the concrete. The finished concrete is tested.

Test conducted

1) Specific gravity.
2) Slump Test.
3) Normal consistency test of cement.
4) Setting time test of cement.

5) Compressive strength of concrete.

Results

1) Specific gravity test

For High Lignin Ash Residue (HLRA)

The specific gravity test was conducted for high lignin residue and the results are tabulated in table 1.

Table 1: Specific gravity test for HLRA

S. No.	Particulars	
1.	Weight of the empty density bottle W1 (gms)	45
2.	Weight of the bottle + water W2 (gms)	155
3.	Weight of the bottle + kerosene W3 (gms)	136
4.	Weight of the bottle +kerosene + ash W4 (gms)	166
5.	Weight of the ash W5 (gms)	50

Results

Specific gravity of kerosene is = 0.827.

Specific gravity of ash = 2.06.

For cement

The specific gravity of cement was conducted to compare with the specific gravity of HLRA. Table 2 shows the results of specific gravity of cement.

Table 2: Results of specific gravity of cement

S. No.	Particulars	
1.	Weight of the empty density bottle W1 (gms)	28
2.	Weight of the bottle + water W2 (gms)	83
3.	Weight of the bottle + kerosene W3 (gms)	71
4.	Weight of bottle + kerosene + cement (w4) gms	60
5.	Weight of the cement W5 (gms)	50

Results

Specific gravity of kerosene is = 0.78.

Specific gravity of cement = 3.12.

2) Slump test

The consistency of the concrete was conducted using slump test. 30% of HLRA and 70% of cement was used in this test. The results is given in table 3:

Table 3: Results of Slump cone test

Water content	Slump (mm)
0.5	0 (true)
0.6	0 (true)
0.7	40 (shear)
0.8	150 (collapse)

3) Normal consistency test

For cement

The test is conducted to find out the amount of water to be added in the cement to get paste of normal consistency. The observations and results are given below:

Table 4: Results of Normal consistency test

S. No.	No of trials	1	2	3	4
1.	Percentage of water	26	28	30	32
2.	Initial Reading (mm)	40	40	40	40
3.	Final Reading (mm)	38	38	31	7
4.	Height Penetrated (mm)	2	2	9	33

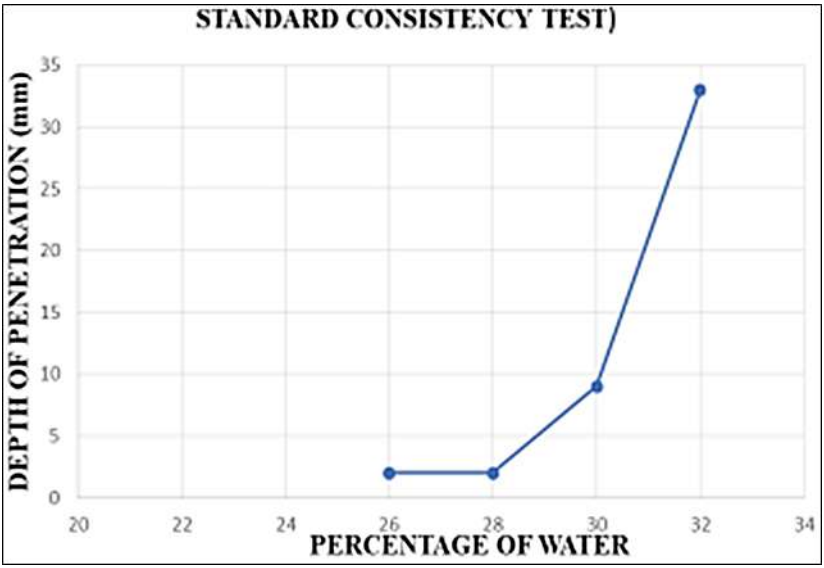

Fig 2: Graph plotted between depth of penetration and water content for cement

Result

The normal consistency of cement P=32%.

For HLRA

The test was conducted to determine the water content for setting time test for HLRA. The results are given in table 5.

Table 5: Water content for setting time test for HLRA

S. No.	No of trials	1	2
1.	Percentage of water	26	28
2.	Initial Reading (mm)	40	40
3.	Final Reading (mm)	31	33
4.	Height Penetrated (mm)	9	7

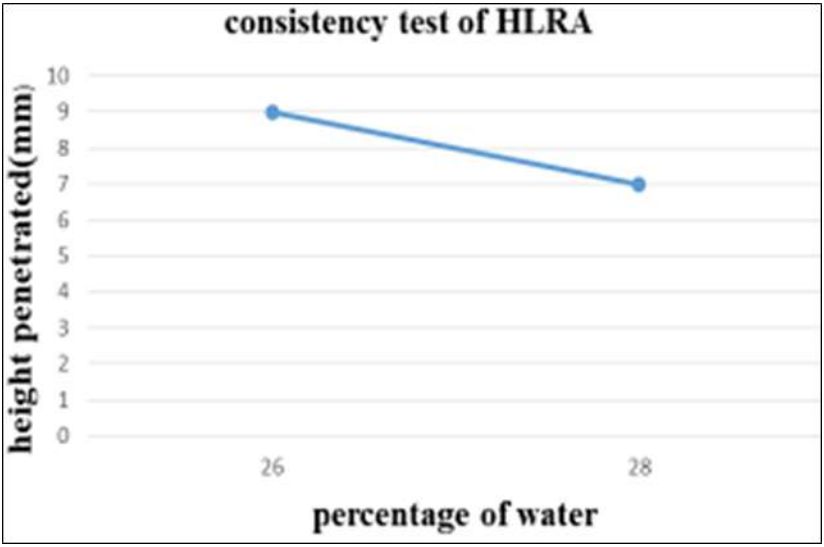

Fig 3: Graph plotted between depth of penetration and water content for HLRA

Result

The normal consistency of ash P= 28%.

4) Setting time test for HLRA

This test was conducted to determine the initial setting time by taking HLRA 90gm of HLRA and 210 gm of cement was taken. The results are tabulated in table 6:

Table 6: Results of HLRA setting time

S. No.	No of trials	1	2	3	4	5
1	Time in minutes	10	10	10	10	8
2	Initial Reading	48	48	48	48	48

3	Final Reading	6	8	11	13	16
4	Height Penetrated(mm)	42	40	37	35	32

Result

The initial setting time of HLRA = 48 minutes.

For cement

This test is conducted to determine and compare the initial setting time of cement with HLRA. The results are given in table 7.

Table 7: Initial setting time for cement

S. No.	No of trials	1	2	3	4	5
1.	Time in minutes	5	5	5	5	10
2.	Initial Reading	48	48	48	48	48
3.	Final Reading	8	10	10	12	16
4.	Height Penetrated (mm)	40	38	38	36	32

Result

The initial setting time of cement is = 30 minutes.

5) Compressive strength test

In this test the cement was partially replaced with HLRA in different percentages and the strength of the concrete was checked and compared. The results are tabulated in table 8.

Table 8: Characteristic strength of concrete in different proportions of high lignin ash

Ash content	Load (KN)	Compressive strength (N/mm^2)
0% ash content	395	17.55
10% ash content	401	17.82
20% ash content	406	18.04
30% ash content	413	18.35

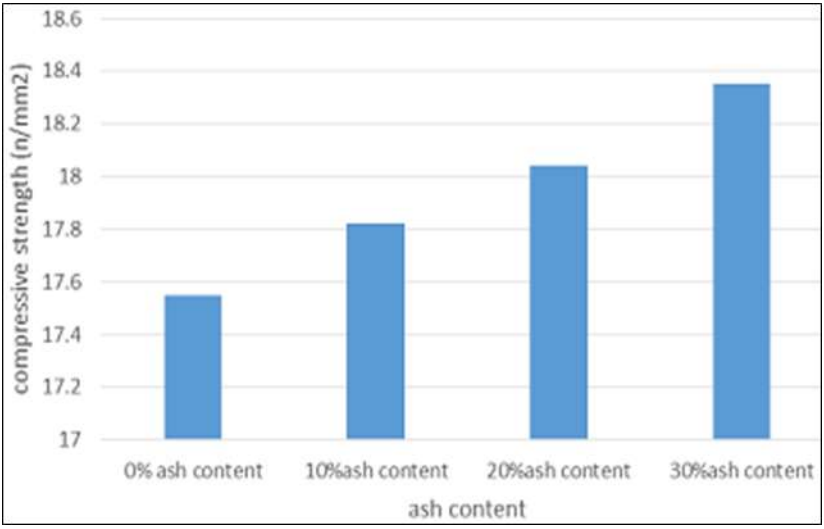

Fig 3: Compressive strength comparison graph

Conclusion

1) It is concluded that the by-product of Ethanol produces a material that can be used in concrete as a partial replacement of cement.
2) The study was conducted with an aim to replace the cement partially with high lignin ash and focus on the properties of the concrete blocks.
3) Cement plays an important role in the compressive strength and behaviour. When high-lignin ash by-product is added to cement, the ash reacts chemically with the cement to make it stronger. Specimens with cement and ash exhibit larger compressive strength.
4) Using high lignin ash material can reduce the amount of cement and thus reduces the carbon footprint.
5) The manufacturing, processing, and construction techniques are still not developed enough to facilitate its uses and this requires extensive amount of research. This type of concrete can be developed as a material which is suitable for concrete pavement, concrete benches and temporary shelters.
6) Hence this type of concrete consumes less energy and becomes more economical.

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Chapter - 2
Medical Tourism in Mumbai

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Chapter - 2

Medical Tourism in Mumbai

Dr. Bushra Abuzar Farouqui

Abstract

Medical Tourism was hardly large enough to be noticed. Today more than 2,50,000 patients per year visit Singapore alone nearly half of them from the Middle East. Every year approximately half a million patients will travel to India. The main aim is to get an overview of the status of Mumbai in the field of Medical Tourism and also to find out what are the future prospects and challenges in Mumbai. The reasons for carrying out the research work are: To find out the factors that drive medical tourism in Mumbai, to identify the problems faced by Medical Tourism in Mumbai, to understand the scope of medical tourism in Mumbai.

Keywords: Ayurveda, allopathy, health care, tourism, medical tourism

Introduction

Tourism is travelling for predominantly recreational or leisure purposes or the provision of services to support this leisure travel. The World Tourism Organisation defines tourists as people who "travel to and stay in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes and not related to the exercise of an activity remunerated from within the place visited".

Tourism is sub-divided into

Leisure Tourism	Medical Tourism	Mass Tourism
Winter Tourism	Pilgrimage	Tourism.

The Ministry of Tourism's Incredible India campaign has lived upto its promise of engaging and catching the imagination of domestic and inbound tourists. The number of foreign tourists arrival has gone up from 2.38 million in the year 2002 to 5.8 million in 2010, while the number of domestic tourists has gone up from 269.60 million in 2002 to 650.04 million in 2009.

Tourism Industry

Economics of tourism

Tourism is the 3rd largest net earner of foreign exchange. Foreign Exchange Earnings during the month of April 2010 were Rs. 4518 crores as compared to Rs. 4061 crores in April 2009 and Rs. 3773 crores in April 2008.

Foreign Exchange Earnings in US$ terms during the month of April 2010 were US$ 1013 million as compared to Foreign Exchange Earnings of US$ 811 million during the month of April 2009 and US$ 943 in April 2008.

Tourism is on its way to strengthening its position as a key contributor in the economy of the country. Outlay for tourism for the 11th 5 year Plan is Rs. 5,156 crores. The Government is today addressing the issue of infrastructure by upgrading existing roads and airports and building new ones.

Medical tourism: A global perspective

The interesting thing of medical tourism is that it is a concept which is actually thousands of years old. In ancient Greece pilgrims and patients came from all over the Mediterranean to the sanctuary of the healing God, Asculapius, at Epidaurus. In Roman Britain patients took a dip in the water at a shrine at Bath, a practice that continued for 200 years as it was believed that the waters have a healing property. From the 18th century wealthy Europeans travelled to Spas from Germany to the Nile. In the 21st century relatively low-cost jet travel has taken the industry beyond the wealthy desperate. Countries that actively promote Medical Tourism include Cuba, Costa Rica, Hungary, India, Israel, Jordan, Lithuania, Malaysia and Thailand. Belgium, Poland and Singapore are now entering the field. South Africa specializes in Medical Safaris.

Neolithic & Bronze Age-Mineral & Hot Spring Visit.

18th & 19th Century-Spa.

20th Century-Health Farm.

Today's Global Market-Medical Tourism.

Medical tourism procedure

Medical tourism in India

20 years ago, Medical Tourism was hardly large enough to be noticed. Today more than 2,50,000 patients per year visit Singapore alone nearly half of them from the Middle East. Every year approximately half a million patients will travel to India. Medical tourism industry according to CII is expected to be worth US$ 4 billion by 2017. India has a potential to attract 1 million health tourists per annum which will contribute US$ 5 billion to the economy. Patients from various countries are becoming medical tourists to India for low cost and restorative alternate treatments. The slogan, thus is, "First World Treatment at Third World prices". The cost differential across the board is huge: only a tenth and sometimes even a sixteenth of the cost in the West. India has a lot of hospitals offering world class treatments in nearly every medical sector. "A recent study by the Federation of Indian Chambers of Commerce and Industry-Ernst & Young shows 15-20% growth for the Indian medical equipment market. It is slated to grow from Rs9,000 crore to Rs 22,500 crore by 2012. Private hospitals are taking the lead in introducing latest technological wonders. With easy access to visa facilities, medical tourism is turning out to be another potential source of income for the healthcare industry," said the official.

For a long promoted for its cultural and scenic beauty, India is now being put up on international map as a heaven for those seeking quality and affordable healthcare.

As Indian corporate hospitals are on par, if not better than the best hospitals in Thailand, Singapore, etc there is scope for improvement, and the country is becoming a preferred medical destination. In addition to the increasingly top-class medical care, a big draw for foreign patients is also the very minimal or hardly any waitlist as is common in European or American hospitals.

The Medical Tourists undergo health restorative treatments of a combination of Ayurveda, Yoga, Acupuncture, Herbal oil massage, Nature

therapies and some ancient Indian healthcare methods such as- Vedic care, an alternate healthcare service. Cost Advantage is the attractive aspect of Indian modern medicine which is 10-15 times lower than anywhere in the world. India can lead the world in medical and health tourism since we have a tremendous advantage with a large pool of skilled manpower and technological edge.

From Yoga to Ayurveda, from several schools of meditation to Naturopathy, Indian culture traditionally believes in Wellness as a way of life and that legacy today makes us one of the major wellness destinations in the world. Recognizing that unregulated institutions claiming to be wellness centres have began mushrooming across the country the Tourism Ministry is encouraging accreditation of Wellness Centres. The guidelines for Accreditation if Wellness Centres have been developed by the National Board for Accreditation of Hospitals and Healthcare Services (NABH) in consultation with AYUSH, which were released by the Ministry in February, 2011. A boom in private hospitals is changing the nation's health delivery landscape beyond recognition.

Comparative pricing for medical services

	Treatment	US ($)	India ($)
1.	Hip Resurfacing	55,000	7,000
2.	LA Hysterectomy	22,000	4,000
3.	Open Heart Surgery (CABG)	1,00,000	7,500
4.	Obesity Surgery (Gastric Bypass)	65,000	9,500
5.	Total Knee Replacement	48,000	6,300

Source: Wockhardt Hospital; www.medicalresortindia.com

A brief comparison of the cost of the Dental Treatment Procedures (Costs in US $)

	Procedure	USA ($)	India ($)
1.	Smile Designing	8,000	1,000
2.	Metal Free Bridge	5,500	500
3.	Dental Implants	3,500	800
4.	Porcelain Mental Bridge	3,000	300
5.	Porcelain Mental Crown	1,000	80
6.	Tooth Impaction	2,000	100
7.	Root Canal Treatment	1,000	100
8.	Tooth Whitening	800	110

Source: Royal Medical Tours (Mumbai) Pvt.

India is not only cheaper but the waiting time is almost NIL. This is due to the private sector, which comprises of hospitals and clinics with the latest technology and best practitioners.

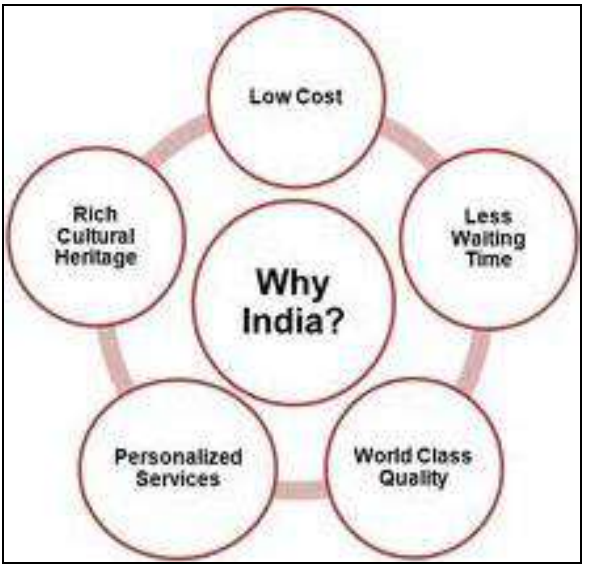
Nature of Treatment	Approximate Cost in India ($)*	Cost in other Major Healthcare Destination ($)*	Approximate Waiting periods in US/UK (in mths).
Open Heart Surgery	4,500 to 8000	18000 to 25,000	9-12
Cranio-facial Surgery and Skull Base	4250 to 6000	13000 to 18,000	6-9
Neuro-surgery with Hypothermia	6,500	>21,000	12-15
Simple Spine Surgery	2,000 to 3,000	>6,500	9-12
Hip Replacement	4,300	>13,000	9-12

Source: Royal Medical Tours (Mumbai) Pvt.

India is not only cheaper but the waiting time is almost nil. This is due to the private sector, which comprises of hospitals and clinics with latest technology and best practitioners.

Over the past few years India has been attracting “Medical Tourists” from countries like US, Europe, Africa and Middle East. What makes this country an attractive medical destination is the fact that the health care industry here has undergone an amazing transformation. World class

hospital, top of the diagnostic and treatment facilities have come up in all the major cities like Mumbai, Bangalore, Delhi, Calcutta, Chandigarh and Chennai.



Today, the sector of medical tourism is growing and the growth is expected to continue. Governmental policies have also helped make India an attractive destination for medical tourists. The Indian Government issues medical visas to facilitate visits for medical purposes. The Ministry of Tourism provides financial support under the Market Development Assistance (MDA) scheme to approved medical tourism service providers; i.e. Representatives of Hospitals accredited by Joint Commission for International Accredited Hospitals (JCI) and National Accredited Board of Hospitals (NABH) and Medical Tourism facilitators (Travel Agents/Tour Operators approved by Ministry of Tourism and engaged in Medical Tourism).

Medical tourism council of Maharashtra

The Maharashtra government in collaboration with FICCI (Western Region Council) has launched the Medical Tourism Council of Maharashtra (MTCM). This council will operate as a nodal agency responsible for smooth operations in the medical-tourism sector besides promoting Maharashtra's health-care facilities and tourism attractions in India and abroad.

Digvijay Khanvilkar, minister for health, medical education and family welfare, government of Maharashtra, said, "The state has state-of-the-art

medical facilities, hospitals and diagnostic centres, highly qualified doctors where quality treatment can be provided at very low costs when compared to treatments in the international market. We also have a strong tourism product in hand that can be utilised to the fullest with the help of various service providers such as hotels, tour operators etc."

Apart from medical and para medical service providers, the hotel industry would also be an essential part of this new venture. Says Sushil Jiwarajka, chairman, FICCI (WRC), "This venture has to be a combined effort from various service providers. Providing accommodation across categories for those visiting India for treatments with their relatives and friends would be essential".

Maharashtra-Medically Yours is the slogan coined for the promotion of MTCM.

Medical tourism in Mumbai

Mumbai is one of the major players in the field of Medical Tourism, and the state has taken immense steps to promote healthcare and tourism in a major way. Mumbai's geographic location makes it a very accessible hub for people coming from, overseas. It has one of the busiest international airports in the world. Mumbai has a number of excellent hospitals and speciality centres like Bombay Hospital and Medical Research Center, Asian Heart Institute, Wockhardt hospital, P D Hinduja Hospital and Medical Research Center, Breach Candy Hospital, Saifee Hospital, Jaslok Hospital, Nanavati Hospital, Lilavati Hospital and Tata Memorial Centre which have seen an increased influx of patients from abroad.

These hospitals have excellent facilities, and the areas of expertise include Cardiology, Cardiothoracic Surgery, Gastroenterology, Neuro Surgery, Plastic Surgery, Obesity Surgery, Oncology and other fields of Medicine.

A good number of these hospitals have collaborations with reputed medical schools in US and UK, and access to international expertise and technology.

Americans are going to Mumbai for healthcare increasing 30-35% per year. Fortis quoted

November 4th, 2010 admin.

Interesting to note in the below article Fortis reported that this growth rate of 30-35% per year does not include the non-resident Indians coming to the country for treatment. those statistics would be very interested to find.

The Americans are coming… for medical treatment Published: Thursday, Nov 4, 2010, 1:14 IST By Somita Pal | Place: Mumbai Agency: DNA

India could soon become a prime health tourism destination for many Americans.

The Americans are increasingly visiting Mumbai for medical treatment, as healthcare facilities are cheaper, compared to the United States.

The Indian healthcare industry hopes that US president Barack Obama's visit will fetch them goodwill and that the American government may look at some form of association.

Fortis Healthcare CEO Vishal Bali said, "There has been a 30-35% rise in American patients being treated in Mumbai per annum. And we are not including non-resident Indians. They find treatment here more affordable, and it is high quality healthcare".

"Healthcare reforms were part of Obama's presidential campaign. With the increasing number of Americans visiting Mumbai for affordable healthcare, the industry in India is looking forward to some form of collaboration with the US," Bali said. Official figures show nearly five lakh Americans came here for cheap treatment in the last one year.

"A cardiac surgery in India costs a foreigner $13,000, including stay and travel. The same surgery in the US costs $55,000-$75,000. While a joint replacement surgery in India costs $9,500, in the US it costs $50,000. With the recent economic slowdown, people in developed countries like the US, are looking for better value for money, and India offers the best deals," said Bali.

Besides, low treatment cost, availability of world-class hospitals with latest technology and skilled doctors, contribute to more foreigners visiting the country for treatment.

A senior tourism ministry official said, "Earlier, people came to India for ayurvedic treatment. The trend of foreigners coming to India for treatment has gained momentum in the last five years. With more multi-specialty hospitals coming up in the country, we are tough competition for medical hotspots like Singapore, Thailand and Malaysia".

The history of patients from America, Iraq and many other countries

An American patient, Misty, who was undergoing spinal surgery at Fortis hospital at Mulund, said, "When the doctors in the US said I need to

undergo spinal surgery, the only option I had was a spinal fusion surgery as disc replacement was not covered under medical insurance because I am self-employed. That's when I thought of looking out for options, at a quality place at an affordable price. I researched on the Internet for almost six months and Fortis came up. My surgery would have cost $200,000 in the US, whereas I have paid $20,000 here, which includes travel, hospital stay and surgery cost".

City Doctors save Iraqi boy's life Published: Friday, 28th May, 2010, Times of India (Mumbai Mirror) pg 08.

In a five-hour long surgery, doctors at Mazagaon's Prince Aly Khan Hospital extracted a 10 centi-meter long tumour from a nine year old Iraqi boy's brain. When the father of the boy was asked the question that why did they not choose to fly to the UK or the USA? The father replied that we would never have been able to afford the high costs involved in such surgeries in those countries.

Blood banks in Mumbai

In Mumbai there are around 21 blood banks which provide 24 hours blood bank facility, this is also one of the positive factor which can help in promoting medical tourism in Mumbai.

1) Ambika Blood Bank.
2) Ambaji Blood Bank.
3) Anviksha Pathological Laboratory.
4) Ashirwad Blood Bank.
5) Balaji Blood Bank.
6) Bandra Holy Family Hospital Society.
7) BARC Hospital.
8) Bhabha Municipal Hospital.
9) Bhatia General Hospital Blood Bank.
10) Bhiwandi Blood Bank.
11) Bombay Hospital Trust Blood Bank.
12) Borivali Blood Bank.
13) B.P.T Blood Bank.
14) Breach Candy Hospital and Research Centre.
15) B.Y.L Nair Hospital.
16) Cama and Albless Hospital Blood Bank.

17) Chhatrapati Shivaji Maharaj Rugnalaya.

Countries from which Patients mostly come

- Nigeria
- UAE
- East Africa
- Yemen
- Iraq
- Dubai
- Qatar
- Tanzania
- USA
- Sweden

Conclusion

The following factors are attracting the international patients to Mumbai-

India for treatment and tourism

1) **Cost benefit:** The prime advantage is the cost savings with respect to medical consultancy or surgeries. Many of the hospitals in Mumbai are serving international patients, have state-of-the-art infrastructure, highly educated doctors and top- notch services but the figure on that price tag is a fraction of what it would be in developed countries. Even if the patient's insurance does not cover the costs of the treatment in India, the final bill in an Indian hospital would most probably be lower than patient's out-of-pocket expenses.
2) **No waiting lists:** Another advantage is the possibility of getting immediate medical attention. There are no waiting lists or delays to contend with, due to insurance issues or unavailability of doctors etc.
3) **Quality health care:** The doctors and paramedics in Mumbai are well trained and are one of the best in the world.
4) **Personalized care:** Here patients are monitored closely with a personal care of all age group.

5) **Technological sophistication:** All the corporate hospitals in Mumbai are having State-of-the-art equipment and infrastructure for the best treatment and diagnosis.

6) **Facilitation by government:** The Government of India has recognized the economic potential of medical tourism. It has facilitated travel by introducing a special visa category known as 'medical visa' for patients as well as introduced tax incentives for hospitals. The Government of Maharashtra have launched the Medical Tourism Council of Maharashtra.

7) **Ease of Travel and Communication:** Travel to Mumbai (India) has become easier and much faster due to introduction of private airlines. Access to Internet in Mumbai is considered to be one of the cheapest in the world and communication facilities are well established. Travel agencies have a great online presence and can offer you package deals that include travel costs, boarding as well as treatment costs.

8) **Easy availability of medicine and drugs:** Certified drugs and medicines are easily available in Mumbai, at comparatively lesser prices.

9) **Modern & Traditional medical treatment available:** Modern medical aid as well as traditional therapy, such as Ayurveda, Yoga, Naturopathy etc, is available at different locations in Mumbai.

10) **Tourism potential:** People, who come for relatively simple, but important procedures, can consider packing in some travel too, with their doctor's permission. This is an added advantage. Every part of the country is rich in history and diverse in geography.

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Chapter - 3
Bioprospecting of Medicinal Insects in North East India

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Chapter - 3

Bioprospecting of Medicinal Insects in North East India

Preety Ekka

Abstract

Insects are traditionally used in the native medicines of different tribal groups in North-East India. Documentation and exploration of such insects through research can identify certain active components that may help in modern medicine. In this chapter an attempt has been made to highlight the different insects used by different ethnic groups in their native medicines. A list of active components that were identified from other insects in other regions of the world is included in the chapter.

Keywords: Medicinal insect, traditional medicine, tribal groups, modern medicine

Introduction

Bioprospecting is essential and helps researchers in exploring and analyzing the indigenous knowledge of tribal practices. Insects are traditionally used in ethnic medicine by different tribal groups. The properties of such medicinal insects can be explored by researchers that may benefit both the pharmaceutical industries with R&D and the host country including the indigenous community. The traditional practitioners can also have ownership of biological resources and can expect compensation for resources used (Convention on Biological Diversity, 1992). The drugs used in modern medicine has its pros and cons. Such studies may lead to finding a new chemical that can have modern medicinal values with the least side effects.

The insects are also emerging as sustainable alternate food and nutraceutical (FAO, 2010) in many countries and have the potential for the future pharmaceutical purposes. Out of the 939 nature derived approved drugs between 1961-2010 like artemisinin, quinine, aspirin, cocodamol, etc. were isolated from plants, marine organisms and microbes but none from insects (Ratcliffe *et al.*, 2014). Review articles on traditional folk medicines, all around the world suggest the tremendous scope of medicinal insect for

bioprospecting. Recent biochemical screening of insects reports the discovery of some bioactive peptides that act as AMPs or ACPs or both. Notable developments of therapeutics from insects are mellitin from bee, alloferon from blow flies, anticoagulants from ticks and further screening on the presence of bioactive peptides and other compounds with its test of effectiveness against diseases are in progress (Ratcliffe *et al*., 2014). This chapter focuses on the insects used in North-east India for treating different ailments.

Scope of North East in discovery of insect derived bioactive peptides

Literature pertaining to therapeutic use of insects and the presence of bioactive peptides in North East India are scanty. Senthilkumar *et al*., 2008 has reviewed the medicinal insects used by the indigenous tribes of India, where tribes of North East India were found to use maximum insects in their folk medicines. The approximate numbers of medicinal insects used by Mishing tribe is seven, Nyashi and Galo tribes is twelve (Doley *et al*., 2012;), Karbis and Rengma Nagas is ten and fifty nine by Ao and Sema Nagas (Hutton, 1921 and Jamir and Lal, 2005) and by the tribal of Khasi and Garo in Meghalaya three species of insects are used (Dey, 2013).

Blatta orientalis (Cockroach) is used by many tribes in North East India for the treatment of asthma and tuberculosis (Jamir and Lal, 2005; Doley and Kalita, 2012 and Dey, 2013). Wasps (*Vespa orientalis)* have been reported to be used in treatment against cold, cough and fever by Nagas and Mishing tribes (Alemla Ao and Singh, 2004; Doley *et al*., 2012). And recent studies at NEIST (Jorhat) on its related species *Vespa affinis*, reported that it extract increases the activity of the detoxifying enzymes i.e. glutathione-s-transferase and catalase, in arthritis patients. But the specific compound of the insect responsible for this activity is still unknown. *Vespa affinis* is also used by some tribes in the North East for joint pain.

Gryllotalpa africana and *Macrotermis* spp. (termite) is used by the Bodos as therapeutic for healing certain childhood diseases (Narzari and Sarmah, 2005). Related species of *Gryllotalpa* spp. and termite are used by Ao-Nagas for wound healing and anemia respectively (Alemla Ao and Singh, 2004). The silkworm pupae of different species are used by tribals of Nagaland as traditional folk medicines to treat stomach disorders (Meyer-Rochow and Changkija, 1997). *Oecophylla smaragdina is* used for the treatment of scabies, malaria, toothache, blood pressure, chicken pox and stomach disorsders by different tribes of NE India (Long, 1901; Doley *et al*., 2012 and Doley and Kalita, 2012). The Sema Nagas were reported to use bee

sting to get rid of abscess and insects like grasshopper and some water insects are used for fever and dysentery respectively (Hutton, 1921). Bodos use rubber like protein (resilins) extracted from insects to repair arteries (Narzari and Sarmah, 2015). The knowledge of using medicinal insects in folk medicines passes from generation to generation within the members of the Bodos tribe only and is not disclosed to others. Certain insects used by the Garo or Khasi tribes of Meghalaya and Bodos of Assam are recognized by common name only such as niang phlang, burbila fisa, hani bere, gunjet etc. and not taxonomically identified. Their proper documentation and taxonomic identification is important for its bioprospecting, which are yet to be done. Molecular screening reports the presence of many bioactive compounds in insect which can be used as potent antibacterial and anticancer drugs. Pierisin, cecropins, defensins and lysozymes are produced by butterflies and cecropin is reported to be cytotoxic against leukemia and lymphoma cells. Such molecular studies of the medicinal insect in Assam are to be done to screen the presence of bioactive compounds with medicinal properties, if any. North East India has huge potential in bioprospecting of medicinal insects. Such studies can give a new direction for future studies in the field of therapeutic uses of medicinal insects.

Table 1: List of the medicinal insects used in North East India.*

English Name	Scientific name	Vernacular/local name (Tribe)	Stages used	Disease	Way of using	Practicing tribes	References
Long horned beetle	*Batocera lubra* Linn.	'Arulangtang' (Ao Nagas)	Larvae	Wounds	Raw insect is eaten	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Trunk borer	*Batocera titana* Thomas.	'Sunglong' (Ao Nagas)	Larvae	Wounds	Raw insect is eaten	Ao and Sema Nagas	Alemla Ao and Singh (2004)
Long horned beetle	*Coelosterna scabrata* Fabr.	'Khuro sukha' (Ao Nagas)	Larvae	Burns	Live insect is crushed and applied externally	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Long horned beetle	*Neocyrambyx paris* Widemann	'Tsukha' (Ao Nagas)	Larvae	Expectorant	In the form of tonic along with other ingredients	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Long horned beetle-Pink wood borer	*Xysterocera globosa* Oliv.	'Arulangtang tasula' (Ao Nagas)	Larvae	Antiseptic	Live insect is crushed and applied externally	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Weevil-Banana weevil	*Balaninus c-album* Heller	'Merong' (Ao Nagas)	Larvae	Respiratory disorders	In the form of tonic along with other ingredients	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Snout beetles-Palm weevil	*Rhynchophorus ferugineus* Oliv.	'Morong' (Ao Nagas)	Larvae	For bronchial catarrh	In the form of tonic along with other	Ao-Nagas	Meyer-Rochow and Changkija (1997)

					ingredients		
Scarab beetles	*Oryctes rhinoceros* Linn.	'Lessepo' (Ao Nagas)	Larvae	Dissipates clots and bruises	Live insect is crushed and applied externally	Ao-Nagas	Maxwell-Lefroy (1971)
Scarab beetle-Hercules beetle	*Xylotrupes gideon* Linn.	'Lessepo' (Ao Nagas)	Larvae	Scrofula and ulcer	In the form of tonic along with other ingredients	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Mantid	*Heirodula coarctata* Saussure	'Aei changkok' (Ao Nagas)	Adult	Resolves bruishes and clots	Live insect is crushed and applied externally	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Mantid	*Heirodula westwoodi* Kirby	'Aei changkok' (Ao Nagas)	Adult	Strengthens kidneys and relieves convulsions	Roasted insects are eaten	Sonowal - Kachari	Gope and Prasad (1983)
Cockroach	*Eupolyphaga sinensis* Walker	'Plau' (Sema Nagas)	Adult	Stop bleeding and heal bone, fractures, swelling	Live insect is crushed and applied externally	Sema- Nagas	Jamir and Lal (2005)
Cockroach	*Blatta orientalis* Linnaeus.	'Leplu' (Ao-Nagas)	Adult	Asthma and T.B. used as local anaesthesia and for internal feverish chills; for breaking up retained blood clots and as a galactogogue (milk	Raw /roasted insects are eaten	Ao -Nagas, Angami, Khiamniungan, Chakhesang Lotha, Zeliang, Poduhury and Rengma Naga	Jamir and Lal (2005)

				inducer)			
		‘Niang kalaw’ (Khasi) ‘Ambitui’ (Garo)	Adult	Asthma	Live/ dry insect is crushed and mixed with water	Khasi and Garo	Dey, 2013
Giant water bugs	*Lethocerus* (=*Belostoma*) *indicus* Lep. & Serv	‘Atsu leplo’ (Ao-Nagas)	Adult	Health tonic	In the form of tonic along with other ingredients	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Giant water bugs	*Belostoma indica*	‘Tsuleplo’ (Ao-Nagas)	Adult	Protein supplement	Roasted insects are eaten	Ao & Sema Nagas	Alemla Ao and Singh (2004)
Sting bug/ Bamboo bug	*Dolycoris indicas* Stal.	‘Pollo’ (Ao-Nagas) ‘Michikha’ (Sema Nagas)	Adult	Paralysis		Ao & Sema Nagas	Alemla Ao and Singh (2004)
Painted bug	*Bagrada picta* Fabr.	‘Tsungi’ (Ao-Nagas)	Adult	Goiters	Eaten cooked	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Sting bug	*Coridius* (=*Aspongopus*) *chinensis* Dall.	‘Tsungi’ (Miris)	Adult	Urino-genital disorder	Eaten cooked	Miris	Distant (1902) Strickland (1932)
Bugs	*Coridius* (=*Aspongopus*) *nepalensis*	‘Tsungi’ (Mishmas)	Adult	Urino-genital disorder	Eaten cooked	Mishmas	Hoffman (1947)
Water Striders	*Gerris spinole* Fab.	‘Tsumeroki’ (Ao-Nagas)	Adult	General weakness	Eaten roasted	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Gmelina bug	*Erthesina fullo* Thunb	‘Tsungi’ (Ao-Nagas)	Adult	Paralysis	Eaten roasted	Ao-Nagas	Hoffman (1947)

Water scorpion	*Nepa cinerea* Linnaeus.	'Tsu meruk' (Ao- Nagas) 'Ghoi' (Sema Nagas)	Adult	Protein supplements	Eaten roasted	Ao & Sema Nagas	Alemla Ao and Singh (2004)
Giant red bug/fire bug	*Lohita grandis* Gray	'Alu tsungi' (Ao-Nagas)	Adult	Stop beelding	Crushed live and applied	Ao- Nagas	Meyer-Rochow and Changkija (1997)
Cicada	*Cicada verides*	'Loyang' (Ao-Nagas)	Adult	For skin disorders, ulcers, utricaria, deafness with running pus from ear, eye. Growth after small pox, indigestion and vomiting and clear lungs.	Crushed live and applied for skin disoreder. Tonic for indigestion.	Ao- Nagas	Meyer-Rochow and Changkija (1997)
Honey bee	*Apis dorsata* Fabr.	'Ninang' (Sema Nagas)	Larva and pupa	Fatigue and sun's heat	In the form of tonic along with other ingredients	Sema Naga	Senthilkumar *et.al.* (2008)
Honey bee		'Ninang' (Sema Nagas)	Sting	Hidden Abscess	Bee are forced to sting on the skin near the abscess	Sema Naga	Hutton (1921)
Honey bee	*Cerana indica* Fabr.	'Ninang' (Ao-Nagas)	Bee sting, bee wax	Arthritis Rheumatoid arthritis	Live insect sting and application of wax on knees	Ao & Sema Nagas	Alemla Ao and Singh (2004)
Honey bee	*Apis mellifera*	'Ninang'	Egg,	Spleen and stomach	Decoction	Ao & Sema	Irvine (1957)

		(Ao- Nagas)	Larva, pupa and bee hive	disorders. Relieves flatulence, counteracts toxicity and kills worms	Live hive	Nagas	
Wasp	*Vespa orientalis* Linneaus	'Ninang' (Ao-Nagas)	Larvae	Arthritis	Crushed live and applied	Ao & Sema Nagas	Alemla Ao and Singh (2004)
		'Borol' (Mishing)	Whole insect, egg or larvae	Cough, cold, stomach problem	Eaten fried	Mishing	Doley and Kalita 2012
Wasp	*Vespa mangifica* Smith	'Nati' (Ao-Nagas)	Larvae	Bone building	In the form of tonic along with other ingredients	Ao & Sema Nagas	Alemla Ao and Singh (2004)
Red ant or weaver ant	*Oecophylla smaragdina* (Fab.)	*Unknown*	Larvae	Resistance to fatigue and sun's heat. Hepatitis B	Tonic or eaten roasted	Ao & Sema Nagas	Long (1901);
Red ant	*Dorylus orientalis*	'Rukkum merong' (Mishing) 'Amroli porua' (Ahom)	Egg, adult	Protect against small pox, chicken pox. Adults used in stomachache and dysentery	Eaten roasted	Mishing & Ahom	Doley and Kalita 2012
Termite	*Odontotermes feae* Wasmann.	'Eesal' (Ao-Nagas) 'Eechalu hula' (Sema Nagas)	Adult	Anemia	Eaten fried	Ao & Sema Nagas	Bodenheimer (1951); Rajan (1987)
Termite	*Macrotermes geilvus* Hagen.	'Anung' (Ao-Nagas)	Adults	Anemia and weakness	Eaten roasted	Ao & Sema Nagas	Alemla Ao and Singh (2004)

		'Alhu' (Sema Nagas)					
Termite	*Microtermes obesi* Holmgren.	'Alhu, (Sema Nagas)	Adult	Antidiarrhoeal agents	Eaten live	Sema Nagas	Bodenheimer (1951)
Tiger Moth	*Diacrisia oblique* Walker	'Wakak' (Ao- Nagas)	Pupa	Cough, shortness of breath	Eaten cooked	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Tent caterpillars, lappet moths	*Malacosoma indica* Walker.	'Mesang-long' (Ao-Nagas)	Pupa	Weak lungs and weak kidney	Eaten cooked	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Mulberry silkworm	*Bombyx mori* (Linn.)	'Mugamesen' (Ao-Nagas)	Pupa	Relieves flatulence and loosens congestion	Eaten cooked	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Giant silkworm	*Antheraea assama* Westwood.	'Mugamesen' (Ao-Nagas)	Pupa	Impotence	Eaten live	Ao-Nagas	Meyer-Rochow and Changkija (1997)
		'Sumani polu' (Mishing)	Pupa	Diet supplement	Cooked	Mishing	Doley and Kalita 2012
Muga silkworm	*Antheraea paphia* (Linn.)	'Mesen' (Ao- Nagas)	Pupa	Diarrhea	Cooked	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Muga silkworm	*Antheraea roylei* Moore	'Sarang mesen'	Pupa	Stomach disorder	Cooked	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Eri Muga	*Samia Cynthia ricini* Hutton.	'Mugamesen' (Ao-Nagas) 'Allishi mesen' (Sema Nagas)	Pupa	Back pain	Cooked	Ao & Sema Nagas	Alemla Ao and Singh (2004)
		'Anera polu' (Mishing)	Pupa	Protect the liver	Cooked	Mishing	Doley and Kalita 2012

Semi looper	*Pericyma cruegri* (Butler)	'Mesen' (Ao-Nagas)	Pupa	Stomach disorder	Cooked	Ao & Sema Nagas	Alemla Ao and Singh (2004)
Darner	*Acisoma panorpoides* Rambur	'Atsu- kumbo' (Ao-Nagas)	Nymph	Blood purifier	In the form of tonic along with other ingredients	Ao- Nagas	Meyer-Rochow and Changkija (1997)
Dragon fly	*Aeschna petalura* Martein	'Anga-mechep' (Ao-Nagas)	Nymph	Anemia	In the form of tonic along with other ingredients	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Rice grasshopper	*Hieroglyphus banian* Fabricious	'Changkok' (Ao-Nagas) 'Atukha' (Sema Nagas)	Nymph and adult	Liver disorder	Roasted	Ao & Sema Nagas	Alemla Ao and Singh (2004)
Grasshopper	*Acrida exaltata* Walker.	'Chupong' (Ao-Nagas)	Nymph and adult	Anamia	Roasted	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Grasshopper		'Aghakimiki-thuka' (Sema Nagas)	Nymph and adult	Fever	Roasted	Sema Naga	Hutton (1921)
Brown locust	*Acridium* (=*Agridium*) *malanocorne* Linn.	'Koropong changkok' (Ao-Nagas)	Nymph and adult	Protein supplement	Roasted	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Locust	*Acridium* (=*Agridium*) *peregrinum* Oliver.	'Wara serpong' (Ao- Nagas)	Nymph and adult	Protein supplement	Roasted	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Locust	*Locusta migratoria*	'Wara serpong'	Nymph	Protein supplement	Roasted	Ao-Nagas	Meyer-Rochow and

	Linn.	(Ao- Nagas)	and adult				Changkija (1997)
Migratory locust/ desert locust	*Schistocerca gregaria* Forskal	'Wara serpong' (Ao- Nagas)	Nymph and adult	Protein supplement	Roasted	Ao-Nagas	Meyer-Rochow and Changkija (1997)
		'Kikambali'(Mishing)	Nymph and adult	Lip cracking	Whole body is crushed and applied externally or its body oil extract is used.	Mishing	Doley and Kalita (2012)
Grasshopper	*Thylotropides vericornis* Walker.	'Aya changkok' (Ao- Nagas)	Nymph and adult	General weakness	Roasted	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Long horned grasshopper	*Holochlora albida* Kirby	'Aya changkok' (Ao- Nagas)	Nymph and adult	Ulcer	Fried	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Bush cricket	*Holochlora indica* Kirby	'Aya changkok' (Ao- Nagas)	Nymph and adult	Ulcer	In the form of tonic along with other ingredients	Ao & Sema Nagas	Gope and Prasad (1983)
Katytids	*Mecapoda elongata* Linn.	'Serapong changkok' (Ao-Nagas)	Nymph and adult	Health tonic	In the form of tonic along with other ingredients	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Katytids	*Lima cordid*	'Alu changkok' (Ao- Nagas)	Nymph and adult	Protein source	Roasted	Ao-Nagas	Meyer-Rochow and Changkija (1997)
House cricket	*Acheta domestica* Linn.	'Chokokza' (Ao-Nagas)	Nymph and adult	Promotes diuresis	Cooked	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Field cricket	*Gryllus bimaculatus*	'Chokok' (Ao-Nagas)	Nymph and adult	Skin diseases	Crushed and applied	Ao & Sema Nagas	Alemla Ao & Singh (2004)

		'Awusho' (Sema Nagas)			externally		
Gryllid	*Brachytrypes portentosus* Licht	'Shati-chokok' (Ao-Nagas)	Nymph and adult	Skin diseases	Crushed and applied externally	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Gryllid	*Gryllodes* singullatus Walker	'Chokok' (Ao-Nagas)	Nymph and adult	Skin diseases	Crushed and applied externally	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Mole cricket	*Liogryllus Saussure* Chopard.	'Metsu-chokok' (Ao-Nagas)	Nymph and adult	Reduces oedema	Crushed and applied externally	Ao-Nagas	Meyer-Rochow and Changkija (1997)
Mole cricket	*Gryllotalpa fossor* Scudder	'Chokok' (Ao-Nagas) 'Sulili' (Sema Nagas)	Nymph and adult	Wound healing	Crushed and applied externally	Ao & Sema Nagas	Alemla Ao & Singh (2004)
Mole cricket	*Gryllotalpa ornate* Walker.	'Chokok' (Ao-Nagas)	Nymph and adult	Wound healing	Crushed and applied externally	Ao & Sema Nagas	Meyer-Rochow and Changkija (1997)
Mole cricket	*Gryllotalpa Africana* (Beauvois)	'Sosroma' (Bodos)	Nymph and adult	Childhood disease		Bodos	Narzari andSarmah (2015)
Water insect		Unknown	Pupa	Dysentary	Eaten	Sema Nagas	Hutton (1921)
Butterfly	-	'Niang phlang' (Khasi)	Larvae, pupa	Stomach Infection	Roasted, powdered and mixed with vegetables	Khasi	Dey, 2013
Dragon fly	-	'Niang kachiah'	Nymph and adult	Irregular urination	Burnt, grounded and paste is	Jaintia	Dey, 2013

					made		
Walking insect	-	-	Nymph and adult	Spasm	Boiled/eaten raw	Garo	Dey, 2013

*Table modified from Senthilkumar *et al.*, 2008 and new entries were made.

Bioactive compounds discovered from Insects:

Table 2: List of bioactive compounds

Sl. No.	Bioactive compound	Nature of the compound	Class of the compound	Action or medicinal value
1	CecropinXJ	Protein	Peptide	Anti-Cancer Peptide
2	Cecropin B	Protein	Peptide	Anti-Cancer and Anti-Microbial Peptide
3	Cecropin 2	Protein	Peptide	Anti-Cancer and Anti-Microbial Peptide
4	Cecropin A	Protein	Peptide	Anti-Cancer and Anti-Microbial Peptide
5	SK84	Protein	Peptide	Anti-Cancer and Anti-Microbial Peptide
6	Alloferon 2	Protein	Peptide	Anti-Cancer and Anti-Microbial Peptide
7	Alloferon 1	Protein	Peptide	Anti-Cancer and Anti-Microbial Peptide
8	AaeAP1	Protein	Peptide	Anti-Cancer Peptide
9	AaeAP2	Protein	Peptide	Anti-Cancer Peptide
10	Stigmurin	Protein	Peptide	Anti-Cancer Peptide
11	Bactericidin B-3	Protein	Peptide	Anti-Microbial Peptide
12	Bactericidin B-4	Protein	Peptide	Anti-Microbial Peptide
13	Bactericidin B-5P	Protein	Peptide	Anti-Microbial Peptide
14	Bombolitin I	Protein	Peptide	Anti-Microbial Peptide
15	Bombolitin II	Protein	Peptide	Anti-Microbial Peptide
16	Bombolitin III	Protein	Peptide	Anti-Microbial Peptide
17	Melittin	Protein	Peptide	Anti-Cancer and Anti-Microbial Peptide
18	Mastoparan B	Protein	Peptide	Anti-Cancer and Anti-Microbial Peptide
19	Mastoparan	Protein	Peptide	Anti-Cancer and Anti-Microbial Peptide
20	Polybia-MPI	Protein	Peptide	Anti-Cancer and Anti-Microbial Peptide
21	Lasioglossin LL-I	Protein	Peptide	Anti-Cancer and Anti-Microbial Peptide
22	Lasioglossin LL-II	Protein	Peptide	Anti-Cancer and Anti-Microbial Peptide
23	Lasioglossin LL-III	Protein	Peptide	Anti-Cancer and Anti-Microbial Peptide
24	Imcroporin	Protein	Peptide	Anti-Cancer and Anti-

				Microbial Peptide
25	Halictine 1	Protein	Peptide	Anti-Cancer and Anti-Microbial Peptide
26	AGAP	Protein	Peptide	Anti-tumor
27	Attacin	Protein	Peptide	Anti-Microbial Peptide
28	Dipteracin	Protein	Peptide	Anti-Microbial Peptide
29	Moricin	Protein	Peptide	Anti-Microbial Peptide
30	Drosomycin	Protein	Peptide	Anti-Microbial Peptide
31	Metchnikowins	Protein	Peptide	Anti-Microbial Peptide
32	Attacin	Protein	Peptide	Anti-Microbial Peptide
33	Lectins	Protein	Peptide	Anti-Microbial Peptide
34	TsAP-1	Protein	Peptide	Anti-Cancerous Peptides
35	TsAP-2	Protein	Peptide	Anti-Cancerous Peptides
36	Halictine 1	Protein	Peptide	Anti-Cancerous Peptides
37	Halictine 2	Protein	Peptide	Anti-Cancerous Peptides
38	Macropin 1	Protein	Peptide	Anti-Cancerous Peptides
39	Macropin 2	Protein	Peptide	Anti-Cancerous Peptides
40	Imcroporin	Protein	Peptide	Anti-Cancerous Peptides
41	Lasioglossin LL-I	Protein	Peptide	Anti-Cancerous Peptides
42	Lasioglossin LL-II	Protein	Peptide	Anti-Cancerous Peptides
43	Lasioglossin LL-III	Protein	Peptide	Anti-Cancerous Peptides
44	Pierisin	Protein	Protein	Anti-Cancerous Peptides
45	Quercetin	Phenol	Flavonols	Anti-Cancerous properties
46	Kaemferol	Phenol	Flavonols	Anti-Cancerous properties
47	Galangin	Phenol	Flavonols	Anti-Cancerous properties
48	Fisetin	Phenol	Flavonols	Anti-Cancerous properties
49	Myricetin	Phenol	Flavonols	Anti-Cancerous

				properties
50	Hesperidin	Phenol	Flavanones	Anti-Cancerous properties
51	Apigenin	Phenol	Flavones	Anti-Cancerous properties
52	Acacetin	Phenol	Flavones	Anti-Cancerous properties
53	Chrysin	Phenol	Flavones	Anti-Cancerous properties
55	Lutcolin	Phenol	Flavones	Anti-Cancerous properties
56	Genkwann	Phenol	Flavones	Anti-Cancerous properties
57	Wogonin	Phenol	Flavones	Anti-Cancerous properties
58	Tricetin	Phenol	Flavones	Anti-Cancerous properties
59	Caffeic acid	Phenol	Phenolic acids	Anti-Cancerous properties
60	Coumarin	Phenol	Coumarins	Anti-Cancerous properties
61	Ellagic acid	Phenol	Tannins	Anti-Cancerous properties

Conclusion

The review suggests the scope for exploring the medicinal insects of North East India in search of such bioactive components. The bioactive peptides isolated from insects have been reported to exhibit different activities and have strong potential as therapeutic agents (Chernysh *et al*., 2002). Such biochemical screening in North East India may discover the components that have the potential to be a new medicine for treating diseases. Very few medicinal insects used in folk medicines have undergone effective clinical trials to prove their efficiency in drug industry. The way the honey components were thoroughly studied through clinical trials, similar studies must be done for other potent insects.

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Chapter - 4
Cancer and Rehabilitation

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Chapter - 4

Cancer and Rehabilitation

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Abstract

Cancer is characterized by uncontrolled cell growth and acquirement of metastatic properties. The majority cases, activation of oncogenes and/or deactivation of tumor suppressor genes result in uncontrolled cell cycle progression and inactivation of apoptotic mechanisms cancers are one of the most destructive effects of human pathologies, presenting the versatile range of hallmark clinical features and responsible for millions of deaths each year around the world.

Keywords: Cancer, physical therapy, rehabilitation, carcinoma

Introduction

Cancer is characterized by uncontrolled cell growth and acquirement of metastatic properties. The majority cases, activation of oncogenes and/or deactivation of tumor suppressor genes result in uncontrolled cell cycle progression and inactivation of apoptotic mechanisms [1].

Cancers are one of the most destructive effects of human pathologies, presenting the versatile range of hallmark clinical features and responsible for millions of deaths each year around the world [2].

According to WHO, Cancer is a major cause of death globally, responsible for almost 10 million deaths in 2020. The most frequently diagnosed types of cancer in 2020:

- Breast (2.26 million cases).
- Lung (2.21 million cases).
- Colon and rectum (1.93 million cases).
- Prostate (1.41 million cases).
- Skin (non-melanoma) (1.20 million cases).
- Stomach (1.09 million cases).

The most frequently causes of cancer death in 2020 were:

- Lung (1.80 million deaths).
- Colon and rectum (916 000 deaths).
- Liver (830 000 deaths).
- Stomach (769 000 deaths).
- Breast (685 000 deaths) [3].

Cancer rehabilitation involves helping a person with cancer to help himself or herself to obtain maximum physical, social, psychological and vocational functioning within the limits imposed by disease and its treatment. Cancer rehabilitation is being provided primarily by oncology and rehabilitation medicine physicians. Additionally, the team is composed of social workers, psychologists, physical therapists, oncology nursing staff, and occupational therapists as a core team with a variety of other disciplines available for specific problem of the cancer patient. Cancer can cause multiple impairments, activity limitations and participation restrictions. Common functional impairments include loss of motor control, cranial nerve deficits, cognitive and speech problems, swallowing problems and sensory loss.

Spinal cord tumors can cause neurological dysfunction including motor, sensory, bowel and bladder impairment similar to traumatic spinal cord injury. Other cancers are more localized in their impact, for instance, head and neck cancers, which can cause difficulties with speech or swallowing. Activity limitations and vocational problems were found to be common in virtually all cancer sites [3]. Activity of daily life (ADL) problems mainly occur in breast cancer, cancer of the respiratory system and cancer of the nervous system which can cause contractures, shortness of breath, paralysis and paresis.

Rehabilitative goals have been divided in restorative, supportive, palliative and preventive.

Studies have demonstrated that progress in lifestyle can help decrease the occurrence of cancer. For example, the risk of cancer can be reduced by exercising at least 3-5 h per week, with women benefiting from proper high-intensity activities, such as heavy housework and dancing, which are considered to be effectual in lowering the risk of breast cancer. A study showed that exercise led to a reduction in the risk of breast cancer ranging from 15% to 20% and a decrease in colorectal cancer by 24% [4].

Currently, aerobic exercise is acknowledged as an effective rehabilitation method for breast cancer patients. Research has indicated that aerobic exercise following breast cancer surgery can enhance upper limb function, cardiopulmonary function, and overall quality of life-5.

Younger patients especially female patients, those with advanced tumors and individuals with certain types of cancer, such as gall bladder, pancreatic, gynecological, head and neck and hematological malignancies, have higher reported rates of Cancer-related fatigue (CRF). Cancer-related fatigue (CRF) is one of the most debilitating consequences of cancer and is considered the most distressing symptom experienced by individuals undergoing cancer treatment [6].

There is mounting evidence to suggest that increasing physical activity can have significant benefits in terms of promoting psychological well-being and physical health in cancer patients. Studies have reported that aerobic exercise, but not resistance exercise, can alleviate pain and insomnia [7].

New research has revealed that regular exercise is a successful approach for enhancing physical fitness, cardiorespiratory fitness, pulmonary function, muscle mass and strength, health-related quality of life (HRQOL), fatigue, psychological status (including anxiety and depression) and sleep quality in individuals who have survived breast, lung, head and neck, ovarian, colorectal and lymphoma cancer during or following treatment [8].

Physical activity can be categorized by intensity, such as light-intensity physical activity (1.5-3 metabolic equivalents of task [METs]) which does not significantly increase heart or respiratory rate (e.g., slow walking), moderate-intensity physical activity (3-6 METs) and vigorous-intensity physical activity (more than 6 METs). Physical activity (PA) has been found to enhance the quality of life, boost aerobic fitness, have a beneficial effect on mental health and decrease the adverse effects of cancer treatment, fatigue and mortality in cancer patients [9].

During acute physical exercise of light to moderate intensity, there is a quick rise in the mobilization of the peripheral activity of the subpopulation of $CD56^{dim}$ NK cells [10].

Both pharmacological and non-pharmacological interventions are available for the management of Cancer Related Fatigue. Pharmacological interventions may include psycho stimulants and corticosteroids, while non-pharmacological interventions may include exercise programs tailored to the individual, modifications to daily activities (such as taking naps), assessments of sleep patterns, stress management and cognitive therapies, and ensuring adequate nutrition and hydration [11].

Exercise may also alleviate symptoms that obstruct with daily life of cancer patients and survivors such as be short of appetite, diarrhea, paresthesia, constipation, physical fatigue, mental fatigue, treatment associated fatigue, muscle pain, arthralgia and other pain, depression, anxiety and insomnia [12].

The American College of Sports Medicine recommends that cancer survivors should follow the Physical Activity Guidelines for Americans, which take in engaging in at least 150 minutes per week of moderate-intensity aerobic exercise, ≥ 75 minutes per week of vigorous-intensity aerobic exercise, or a combination of both. This can help improve physical fitness, cardiopulmonary function, pulmonary function, muscle mass and strength, health-related quality of life, fatigue, psychological status and sleep quality in cancer survivors during or after treatment [13].

Research has demonstrated that low-intensity exercise can enhance depression, anxiety and overall physical functioning. On the other hand, moderate-to-vigorous exercise has been found to be effective in improving physical function and decreasing cancer-related consequences [14].

The study found that two supervised sessions, including a 30-minute aerobic workout and a 20-minute resistance training, were more effective than three 30-minute aerobic workouts at home. The authors concluded that both types of training were effective in facilitating a quicker return to work and reducing nausea, vomiting and pain after chemotherapy, compared to a sedentary approach [15].

The benefits of aerobic exercise on physical fitness, muscle strength, and quality of life have been demonstrated in breast cancer patients receiving chemotherapy, but its effects on colorectal cancer (CRC) patients undergoing chemotherapy are not well understood [16].

Preclinical studies have been accumulating evidence that suggests a relationship between regular exercise and the development of cancer or the progression of tumor growth after malignancy has begun [17].

The American Cancer Society recommends that adults engage in at least 150 minutes of moderate intensity or 75 minutes of vigorous intensity activity per week, which is equivalent to 7.5 to 15 MET-hours/week. Studies have found that meeting these guidelines is associated with a reduced risk of several cancers, including colon (in both men and women), breast, endometrial, kidney, bladder, esophageal, stomach and lung cancers, as well as myeloma, liver and non-Hodgkin lymphoma [18].

Fatigue is a common side effect of cancer treatment with chemotherapy and radiation therapy, as well as selected biologic response modifiers. In fact, it is the most common side effect reported by cancer patients. Fatigue can have a significant impact on a patient's quality of life and daily activities, making it an important symptom to address during cancer treatment [19].

Cancer patients often experience a range of symptoms related to their illness and treatment, and fatigue is one of the most commonly reported. This can be due to a variety of factors, including the physical and emotional toll of cancer treatment, as well as the impact of the disease itself on the body. Despite its prevalence, fatigue is often undertreated in cancer patients. It is important for healthcare providers to assess and address this symptom to improve patients' quality of life and overall outcomes. In conclusion, fatigue is a significant symptom experienced by many cancer patients undergoing treatment. It is essential for healthcare providers to recognize and manage this side effect to improve patient outcomes and quality of life [20].

Exercise may decrease feelings of depression, tension, anxiety, anger, hostility, helplessness and pessimism and improve the social dimension of QOL in cancer patients. Psychostimulants, corticosteroids and exercises, as well as assessment of sleep patterns, stress management and cognitive therapies and adequate nutrition and hydration are available to manage cancer related fatigue [21-25].

Deconditioning is a term used to describe the reduced functional capacity of bodily systems and it is considered a separate entity from the condition that led to the inactivity in the first place. Early intervention can prevent problems [26-28].

Aerobics exercises can reduce fatigue and global psychological distress in patients undergoing chemotherapy and adaptative aids can be prescribed to improve activities of daily living. Peripheral neuropathy can be treated with special neurophysiological exercises and orthoses [29-30].

A 12-week program of moderate/vigorous-intensity aerobic training (55-100% VO2max, 20-45 min, 3 times/week) led to a significant increase in VO2max (from 19.5 ± 7.6 to 22.1 ± 7.0 $mL \cdot kg^{-1} \cdot min^{-1}$) among women with breast cancer undergoing chemotherapy [31].

Previous studies have demonstrated that aerobic exercise can lead to improvements in VO2 max among women with breast cancer. Exercise has shown effectiveness in a range of aspects of treatment, such as weight loss, body mass index reduction, body fat reduction and improvements in physical measurements and cardiorespiratory fitness. The positive effects of exercise

on cardiac function include enhanced skeletal muscle function, improved endothelial function, increased autonomic nervous system function, decreased levels of inflammatory cytokines, increased muscle strength, and reduced mortality rates [32].

Isometric handgrip maximal strength serves as an indicator of overall muscle strength, and lower values have been associated with higher risks of all-cause and cancer mortality, including breast cancer [33].

Current scientific research supports the inclusion of exercise programs that combine both resistance training and aerobic exercises for individuals diagnosed with breast cancer [34].

Existing evidence indicates that engaging in aerobic exercise is linked to a decreased risk of tumor development. Moreover, aerobic exercise has been found to impact tumor physiology and contribute to the control of disease progression. These effects are associated with the inhibition of tumor metastasis and recurrence [35].

Numerous researchers have investigated the impact of aerobic training, which involves exercises that engage large muscle groups, such as supervised treadmill workouts and leg pedaling exercises. Additionally, studies have explored the effects of resistance training on fatigue levels and quality of life in breast cancer survivors, using various methods such as free weights, machine-based resistance and Therabands. It has been observed that both aerobic and resistance training are effective in reducing cancer-related fatigue [36].

Research involving breast cancer survivors has shown that engaging in cognitive training for a period of 12 weeks can lead to significant improvements in cognitive function. Specifically, cognitive training has been found to enhance performance in tasks such as the Wisconsin Card Sorting Test, letter fluency and the symbol search test. These findings suggest that both aerobic exercise and cognitive training have the potential to positively impact cognitive abilities in breast cancer survivors [37].

Research indicates that exercise stimulates oxidative stress (OS) by amplifying muscular and intracellular activity in response to the physical demands and energy requirements placed on the body [38].

In a study conducted over 26 weeks, it was observed that the training group experienced a decrease of 0.3 $mL \cdot kg^{-1} \cdot min^{-1}$ in VO2max, while the UC (usual care) group showed an increase of 0.2 $mL \cdot kg^{-1} \cdot min^{-1}$. In contrast, a separate study by Jones *et al*. demonstrated that 12 weeks of

moderate/vigorous-intensity aerobic training (55-100% VO2max, 20-45 min, 3 times/week) led to an increase in VO2max from 19.5 ± 7.6 to 22.1 ± 7.0 $mL \cdot kg^{-1} \cdot min^{-1}$ in women with breast cancer undergoing chemotherapy. These findings suggest that the intensity of aerobic training may play a role in improving VO2max in women with breast cancer undergoing chemotherapy [39].

According to the American College of Sports Medicine (ACSM), exercise training has a wide range of positive effects and can contribute to improving the quality of life and reducing cancer-related fatigue in cancer survivors [40].

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Chapter - 5
Ionic Liquids' Critical Micelle Concentration and Micellisation Thermodynamics

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Chapter - 5

Ionic Liquids' Critical Micelle Concentration and Micellisation Thermodynamics

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Abstract

The journey of distinct cations and anions in ionic liquids (ILs) is addressed. Ionic liquids with surface activity are then discussed. Ionic liquids have been tuned in accordance with the applications' concerns. The writers chose the aforementioned subject because they believe there is a lot of work that can be done in accordance with it for the benefit of the applications. The history of ionic liquids, their development and structural modifications are covered at the beginning of the chapter. By selecting the proper cationic and anionic moiety, the tuning of ionic liquids has finally been completed. The reasons for choosing a specific ionic liquid have been described in the following section in terms of its aggregation/micellization behavior, as well as factors influencing this behavior. Finally, the thermodynamic parameters provide an excellent understanding of how ionic liquids behave both with and without additions. In order to create better formulations for electrolytes, sensors and medicines, the authors' work stated above will assist other authors in tuning their works and assisting them in thermodynamic investigations.

Keywords: Ionic liquids, critical micelle concentration, surface active ionic liquids and thermodynamics of micellisation

1. Introduction

Whatever "ionic liquids" (ILs) are, it is certain that there has been a surge interest in them. Ionic liquids suggest to be a sophisticated and intriguing family of solvents. A consistent reporting rate of 20 articles per year for "ILs" existed in 1995, but by 2001, that number had increased to 300. The knowledge that these liquids, previously used in some electrochemical applications, may be used as reaction solvents is unquestionably the cause of the intense interest. ILs can be defined arbitrarily as salts that melt below the boiling point of water and make few claims about the constituents of substrates other than their ionic character. The fundamental property of ILs is their

enlarged liquidus range, which is typical of well-known molten salts. Between the melting point and the boiling point is the liquidus range. IL can be distinguished from molten salts due to the latter's wide liquidus range. The most popular and widely used term for ionic compounds in liquid form is molten salts. For the salts that are liquid at or near room temperature, the ILs received a separately designated space. Practically, ILs can be handled similarly to conventional solvents while retaining their distinctive characteristics, such as strong ionic interactions and a greater melting point for salts than for ILs. The words "low-temperature molten salt", "room temperature molten salt", "liquid organic salt" and "ambient-temperature molten salt" are also used in literature to refer to ILs that meet the necessary criteria of IL. Even while ILs' physical and chemical properties exhibit a wide range, their general makeup is surprisingly consistent. An organic cation and an inorganic, polyatomic anion are both present in the majority of ILs. Given the abundance of probable cations and anions, there could be a very large number of IL. Finding a novel IL is not difficult, but its utility depends on being able to identify its physical and chemical characteristics. The ideal approach is to adjust the cation and anion, giving IL a special set of properties.

Therefore, in order to employ ILs in various applications, it is imperative to comprehend their structure, which can be accomplished with the aid of computational methods. In Friedel-Crafts reactions, "red oil" was identified as the earliest substance that functions as IL. Additionally, it was recently discovered to exist as a salt with the use of NMR spectroscopy.

Alkylammonium nitrate salts were liquid around the turn of the 20th century (Walden, 1914) and more recently, binary nitrate IL liquid gun propellants have been developed (Wilkes, 2002). Also, John Yoke *et al*. published a paper in 1963 asserting that the union of copper (I) chloride and alkylammonium chlorides existed as liquids in the late 1960s.

In the following decade, "liquid clathrates" were created by Jerry Atwood in 1976 by fusing aluminium alkyl with one or more aromatic moiety and a halide salt. Chloroaluminates, another remarkable class of salts made up of anionic moieties Cl^-, $[AlCl_4]^-$, $[Al_2Cl_7]^-$ and $[Al_3Cl_{10}]^-$, demonstrated Lewis-base chemistry and were used as battery electrolytes. IL has melting temperatures below ambient temperature throughout a wide composition range when another class of cations, dialkylimidazolium, namely 1-ethyl-3-methylimidazolium, fuses with $AlCl_3$ [Wilkies *et al*., 1982]. Then, reports from the literature demonstrated that ILs behave in several organic reactions as both catalysts and solvents [Boon *et al*., 1986].

Chiral ILs with amino acids and imidazolium as a cationic moiety were initially created by Bao *et al*. in 2003. Fukumoto *et al*., 2005 created amino acids-based ILs, using 1-ethylimidazolium as the cationic component and amino acids as the anionic component. This leads to the beginning of the development of bi-functional amino acid-based ILs, where the cationic component was supplied by ammonium, phosphonium and pyrolidinium and where amino acids can also act as cations containing Cl^-, NO_3^-, BF_4^-, PF_6^-, $1/2SO_4^{2-}$ and CF_3COO^- anions. Strong attempts were made to produce the ILs with the intention of having carboxylic acid esterifications damage the hydrogen bonding after seeing the phenomenon of hydrogen bonding between carboxylic acids and anions. Task-specific ionic liquids (TSILs), a new class of ILs with applications in magnetism, catalysis, luminescence, separation, and other fields, were created as a result. Additionally, the catalytic and magnetic characteristics of ILs were enhanced by the addition of transition metals. The article written by Okuno *et al*., 2006 explaining the magnetic behavior of "1-butyl-3-methylimidazolium tetrachloroferrate $[C_4mim][FeCl_4]$" where they documented its application in separating non-magnetic impurity, shows the existence of the magnetic behavior of IL.

After then, a brand-new class of "polymeric ionic liquids (PILs)" was created by joining cations or anions in polymeric strings and employed in the production of lithium batteries, light-emitting diodes, solar cells, and other types of electronic devices. [Watanabe *et al*., 1995; Ito *et al*., 2000; Washiro *et al*., 2004; Ricks-Laskoski and Snow, 2006; Pont *et al*., 2009; Mecerreyes, 2011; Yuan and Antonietti, 2011] are a few examples of studies that support this claim. A crucial class of TSILs known as "surface active ionic liquids (SAILs)" will be covered in the following section. SAILs display aggregation behavior and have far-reaching applications in numerous fields. Despite the fact that ILs have several uses in practically every area of science, concerns remain regarding their biological activity and toxicity. That, these issues were later resolved by creating biologically active ILs from active pharmaceutical ingredients (API) [Hough *et al*., 2007].

They also suggested that these ILs' tuning properties, which were helpful in lowering the toxicity, be used. These ILs were thereafter vigorously developed without looking back, with surpassing applications in practically every branch of science. The scientific community has taken notice of ILs because of their distinctive physicochemical characteristics, such as their wide electrochemical window, high ionic conductivity, high thermal stability, non-flammability, negligible vapor pressure, strong solvents and effective electrolytes, among others. They also have low toxicity, antibacterial activity,

biocatalysts, organic synthesis, and superior uses in extraction and separation, in addition to these all-encompassing qualities.

By carefully choosing the right anions and cations, these properties can be changed to suit the needs of various applications. These ionic liquids are sometimes referred to as designer solvents because of this tailoring property. Those ILs with a long alkyl chain also display another peculiar characteristic of self-aggregation, which is another factor contributing to their inherently amphiphilic nature. These ILs are essentially made up of a hydrophobic tail and a hydrophilic head due to their amphiphilic nature. A SAIL's general structure is shown in Fig. 1.

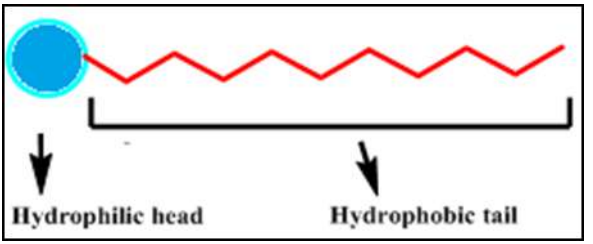

Fig 1: The general structure of a surface-active ionic liquid (SAIL)

They are hydrophobic and exhibit aggregation behavior due to their long aliphatic alkyl chain, which typically contains 8 to 18 carbon atoms. Through hydrogen bonds, electrostatic interactions, or dipole interactions, the polar head group communicates with the water or solvent. The length of the alkyl chain, the type of polar head group, and the accompanying counter-ions all have a considerable impact on the physicochemical characteristics of these SAILs. Wide-ranging research on "the aggregation behavior of ILs" in the aqueous system has revealed that they have more uses than surfactants. Micellar liquid chromatography (MLC), colloid and interface sciences, etc. are only a few of the chromatographic applications that "The aggregation behavior of ILs" in the presence of "organic solvents" demonstrates.

2. The term Surface Active Ionic Liquids (SAILs)

Since they contain long alkyl chains in either their cationic, anionic, or both portions, surface active ionic liquids have the ability to lower the surface tension of a solution. They become slightly more significant due to their tunability characteristic. They aggregate in various sizes due to their amphiphilicity, just like surfactants. The molecular makeup of ILs determines whether these aggregates are simple aggregates, micelles, vesicles, lamellar sheets, etc. According to the connected alkyl chain to the ion, SAILs are often divided into three categories: cationic, anionic and bi-amphiphilic as shown in Fig. 2.

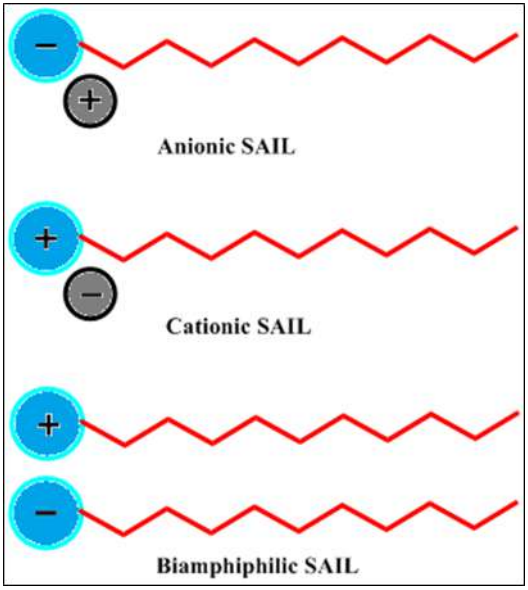

Fig 2: General construction of various SAIL kinds

2.1 An anionic surface-active ionic liquid (SAIL) is made up of an anionic component with a long alkyl chain that is neutralized by a counter-ion cation. The first anionic SAIL, 1-butyl-3-methylimidazolium octylsulfate [C_4mim][C_8OSO_3], was described by Roger *et al*. in 2002. Miskolczy *et al*. explored its aggregation or surface-active activity in 2004. Dodecylbenzenesulphonate, alkoxycarboxylates, dodecylsulfate, bis(2-ethylhexyl)phosphate and dioctylsulfosuccinate are a few further examples of anionic SAILs. Common cations include amino acids, imidazolium and ammonium. The few instances of anionic SAILs are shown in the following Fig. 3:

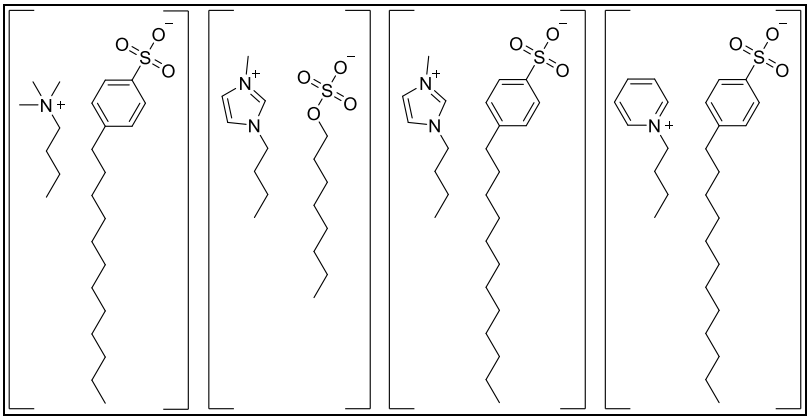

Fig 3: Anionic SAILs with several common structures

2.2 The second is cationic surface-active ionic liquids: The group of cationic SAILs includes ILs with long alkyl chains in their cationic portion. Imidazolium, ammonium, pyridinium, and phosphonium are the main cationic parts of ILs, each of which has a variety of long alkyl chains and a range of various anions. Fig. 4 provides the cationic SAILs' structures.

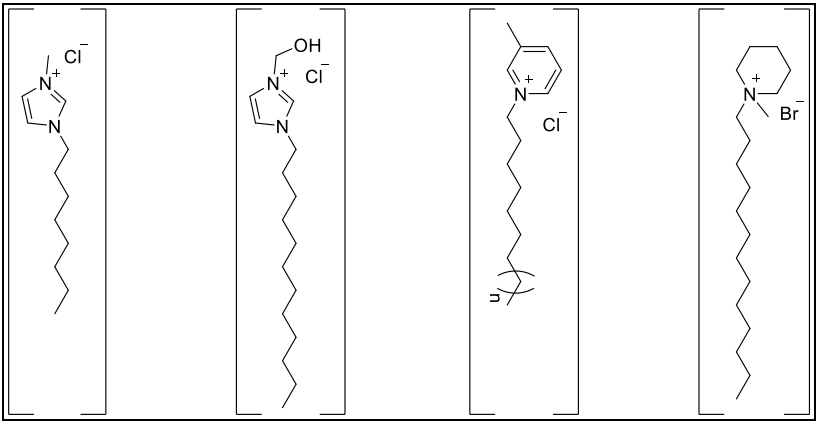

Fig 4: Shows the structures of various typical cationic SAILs

These ILs' aggregation behavior is entirely dependent on the alkyl chain length, IL anions, and IL cations. Their characteristics can be enhanced by subtle changes to the ILs' alkyl chains and ions. In comparison to traditional surfactants, these SAILs are shown to have improved surface activity and antibacterial action.

2.3 Surface-active ionic liquids that are biamphiphilic (BAILs)

This class of SAILs consists of ILs with long alkyl chains in both the cationic and anionic portions. The first bi-amphiphilic SAIL was described by Villa and colleagues [Villa *et al*., 2012] as benzyl-n-hexadecyldimethylammonium dioctylsuccinate [BHD][AOT]. The cationic component of these surface-active ionic liquids (SAILs) may contain imidazolium and ammonium ions, whereas the anionic component may contain laurylsulfate, octylsulfate, and dioctylsulfosuccinate (AOT). The paper on imidazolium-based BAILs showed how micelles, vesicles, and loose aggregates can form in aqueous solutions. The interactional behavior of these BAILs was investigated by Rao *et al*., 2012; Brown *et al*., 2013 and Villa *et al*., 2014. The following Fig. 5 depicts some examples of BAILs.

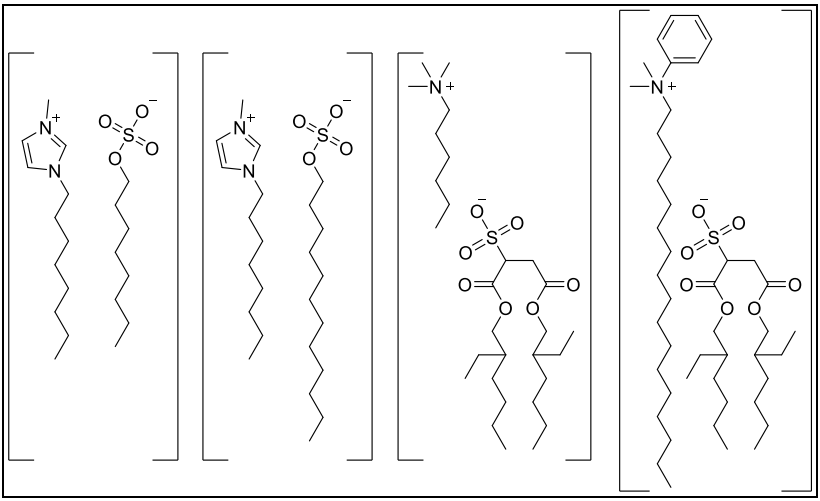

Fig 5: The general structure of several BAILs

The aforementioned papers demonstrate a variety of benefits that SAILs have over traditional surfactants due to their tunability. Due to their superior applicability in the fields of nanomaterial production, pharmaceutical formulations, drug delivery, separation processes, chromatographic application, in the field of colloid, interfaces science, etc., their self-aggregation behavior has drawn the attention of the scientific community.

3. Critical micelle concentration (CMC)

To describe the colloidal phenomena seen in scope and detergents, J.W. McBain was the first to use the term micelle [McBain and Salmon, 1920]. The word micelle is of Latin origin and means "small bit." Surfactant and IL molecules began to appear and cover the whole surface of the solvent as soon

as they were added to the water-based solvent. In the absence of space at the surface, they tend to travel in the bulk phase with the subsequent addition of a surfactant or IL molecules. One of the micelle molecules is hydrophilic, whereas the other is hydrophobic. The hydrophilic portion (head of the molecule) is still in the solution at the surface, and the hydrophobic portion is present with its tail pointing up and outside the solution. In the bulk phase, two opposing forces are at work: the hydrophilic component attracts water molecules, whilst the hydrophobic component repels them. The interaction of these two pressures causes aggregation formation by drawing molecules' hydrophobic regions closer to one another. Critical aggregation concentration (CAC) or critical micelle concentration (CMC) refers to the concentration at which this aggregation process begins. The length of the alkyl chain is what determines whether the terms CAC or CMC are used in aqueous solutions of ILs.

If there are 8 or more C-atoms in the alkyl chain length, the word CMC is used; if there are less than 8, the term CAC is used. When a surfactant or IL is introduced to water used as a solvent, the micellization phenomenon occurs. These surfactants, also known as ILs, tend to assemble in a fashion where the head groups are present in the core and the tail occupies its place at the surface of the oil when the solvent is changed from water to oil. Fig.6 shows the micelle's whole structure, including its hydrophobic core, outer and inner palisade layers, stern layer and micelle interface.

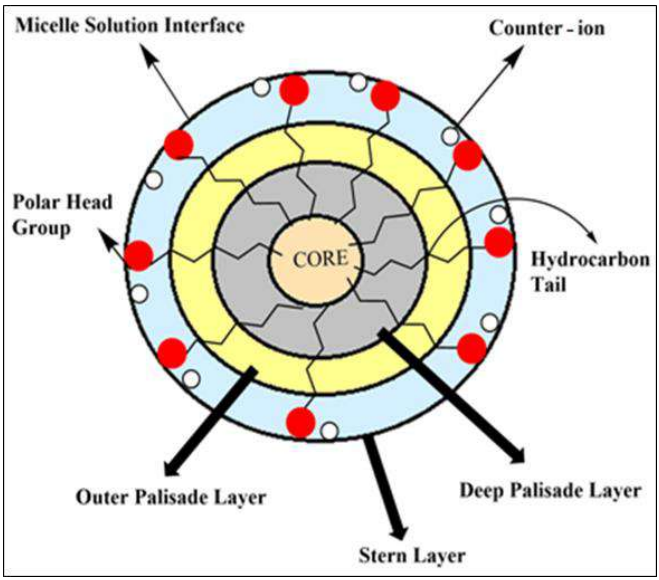

Fig 6: A spherical micelle's general structure

The CAC or CMC is a crucial parameter that causes significant changes in physicochemical properties like light scattering, conductivity, surface tension, spectral behavior and turbidity [Romsted, 1977; Tadros *et al*., 1984; Schick, 1987; Lucassen-Reynders, 1991; Kronberg and Lindman, 2003; Rosen, 2012]. The Fig. 7 displays the graphs of the physical and chemical characteristics with the concentration of IL, with the CMC breakpoint.

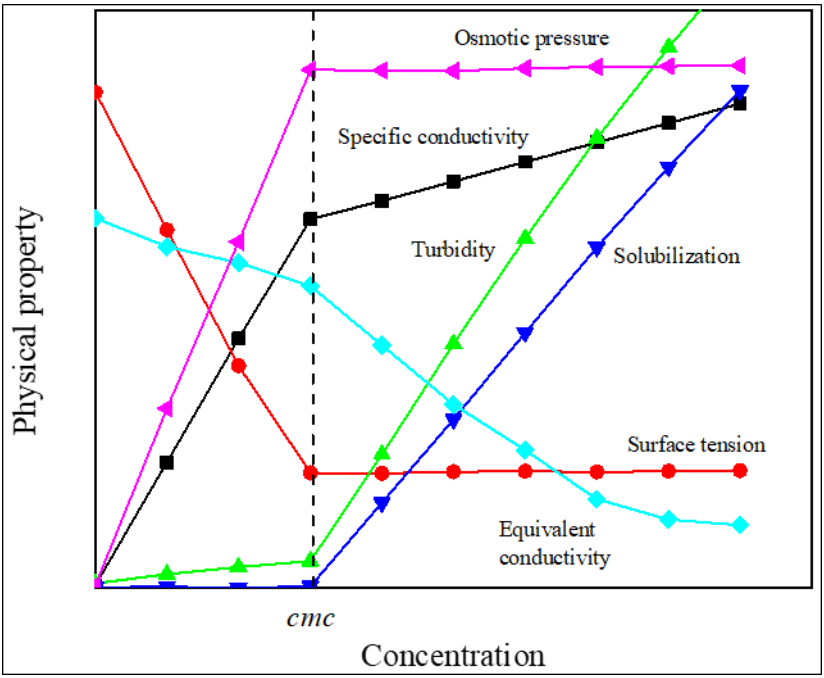

Fig 7: The relationship between variations in several physicochemical properties and IL content

4. Factors affecting critical CAC/CMC

The fundamental parameter that can be used to interpret the processes taking place at the interface and ultimately lead to the interpretation of various physicochemical features is the CAC/CMC. However, CAC/CMC is particularly vulnerable to experimental settings. Here are some of the elements that could alter CAC/CMC:

a) IL composition: Since the number of carbon atoms in the hydrophobic region of the IL determines the CAC or CMC. The CMC typically declines as the hydrophobic section grows longer (up to 16 carbon atoms). A rise in carbon atoms above 16 causes the aqueous solution to become turbid, and the CMC of IL then becomes constant.

b) **Organic solvents:** Numerous research studies in the literature at the moment describe how the presence of organic solvent affects the CAC/CMC value of IL. Organic solvents have a tendency to alter CMC either by assimilating into the micelle or by interacting with the micelle or the IL. Organic solvent-IL interactions are found to increase with the presence of organic solvent, according to Pino *et al*., 2009. In addition, according to Wang *et al*. (2010), organic solvents such ethylene glycol, N,N-dimethylformamide, formamide, dimethylsulfoxide, and acetonitrile have attractive interactions with the IL that are beneficial and raise CMC.

c) **Temperature:** The temperature has an impact on the CAC/CMC of IL. In actuality, two opposing variables combine to produce the temperature effect on CMC. First, a change in temperature reduces the head group's degree of hydration, increasing the hydrophobicity of IL and leading to more aggregation. The presence of water molecules surrounding the alkyl chain is the second factor. Due to the alteration in water structure, the aggregation process is inhibited, which causes the CMC to rise. The sum of these two components determines whether CMC increases or decreases at a given temperature.

d) **Electrolytes:** The addition of electrolytes is another component that has the ability to alter the CMC of IL. For ILs, the addition of electrolyte results in a drop in the attraction between charged head groups at the micelle's edge, which lowers CMC. In actuality, the action of electrolyte addition followed by the hydration of head groups on the water structure is what causes the two phenomena of salting in and salting out. CMC increases during monomer salting-in events while CMC decreases during monomer salting-out phenomena. Both IL and the type of ions present in salts have a significant impact on the aggregation phenomenon of IL. Wang *et al*., 2010 described the effects of electrolytes on IL and came to the conclusion that, depending on the type of electrolyte employed, both the salting-in and salting-out phenomenon can be seen.

e) **Drugs:** The presence of medicines is another factor affecting changes in the IL aggregation in terms of CAC/CMC. Since the majority of medicines have an amphiphilic character, they interact with ILs to generate a mixed micellization. Additionally, the complex's CAC/CMC value falls in the middle of that of pure medicines and pure ILs. The presence of anion-, cation-, and H-bonding interactions

in drug-IL complexes is discovered. Alam and Mandal (2012), Patel *et al*. (2013), Mahajan *et al*. (2012), Mahajan and Mahajan (2012), Mahajan *et al*. (2013) all reported the existence of synergistic relationships governing the mixed micellization process between the medicines and ILs. Acetylcholine chloride (AC), amitriptyline hydrochloride (AMT), diclofenac sodium (DfNa), dopamine hydrochloride (DH), promethazine hydrochloride (PMT), ibuprofen (Ibu), trifluoperazine dihydrochloride (TFP), and promazine hydrochloride (PMZ) are among the medications that have undergone the most comprehensive research.

f) **Surfactant effect:** By incorporating another surfactant into the solution, the CAC/CMC value of the IL can be altered. When another surfactant is added, mixed micellization events are typically seen. Compared to the micelle of IL, mixed micelle appears to be more adaptable. As of right now, only SDS is used as a second surfactant, and its impact on the aggregation of IL with various alkyl chain lengths has been researched. "In this case, mixed micellization phenomena showed the potential of ILs in the tuned modification of conventional micelle properties, which is needed for many applications".

5. Thermodynamics of micellization

It is vital to have a thermodynamic understanding of aggregation/micellization with the aid of "Gibbs energy, enthalpy, and entropy of micellization" in order to comprehend the driving force in the spontaneity of aggregation as well as certain molecular specifics of the aggregation/micellization events of IL. Thermodynamic parameters can be used to observe the fluctuation in chain length of cationic and anionic part of IL. These parameters can be obtained by using the pseudo phase separation model and methods that change the CAC/CMC of IL. When the CAC/CMC value of classical ILs was calculated using the electrical conductivity method, it was found that the CMC value first decreases in value up to a certain point. Following this, the CMC value rises with temperature, yielding a U-shaped dependence with a minimum temperature Tmim that is near to room temperature. Additionally, the CAC/CMC against temperature plot's curve shapes exhibits the same pattern.

Two conflicting criteria control how temperature affects the CAC/CMC value of IL in aqueous solution. The degree of hydration of the imidazolium head group, which decreases as temperature rises due to an increase in the hydrophobicity of the cationic portion of IL, is the first factor. Because of this,

aggregation is encouraged and happens at a lower concentration. The second factor defines the structural configuration of the water surrounding the hydrophobic component. Disruption of structured water is caused by temperature increase. Entropy rises as a result, impairing IL's self-association mechanism and preventing aggregation. Therefore, it can be concluded that the first component dominates at lower temperatures while the second factor is visible at temperatures exceeding Tm. Entropy-driven events, which jointly comprise the contribution of Gibbs energy and enthalpy components, can be used to better understand thermodynamic characteristics. Additionally, the electrostatic and hydrophobic forces control the aggregation process and contribute to the Gibbs energy as a result. Tanford correctly analyzed the thermodynamics of micelle production in the year 1980. As a result, equilibrium between micelles and surfactant/IL monomers is hypothesized to exist as;

$$\left\{\frac{(n-N)}{N_A}\right\}\text{monomer} \underset{}{\overset{K_M}{\rightleftharpoons}} \left(\frac{N}{rN_A}\right)\text{micelle} \qquad \text{(i)}$$

Where n is the number of surfactant/IL molecules, N is the number of IL/surfactant molecules completely consumed, N_A stands for the Avogadro number, and r is the average aggregation number.

The concentration equilibrium constant K_M may be represented as

$$K_M = \frac{(\text{micelle})^x}{(\text{monomer})^y} \qquad \text{(ii)}$$

Where $x = N/rN_A$ and $y = (n-N)/N_A$.

The definition of free energy of micellization is

$$\Delta G_m^o = -RT \ln K_M \qquad \text{(iii)}$$

Equation (iv) is produced by combining equations (ii) and (iii).

$$\Delta G_m^o = -RT\{x \ln(micelle) - y \ln(monomer)\} \qquad \text{(iv)}$$

Where T represents absolute temperature and R represents a universal gas constant. By applying limiting conditions such as $N \to 0$, $Lim_{micelle} \to 0$, and $y \ln(monomer) \to \ln_{CMC}$, equation (iv) gets reduced and it becomes"

$$\Delta G_m^o = RT \ln K_{CMC} \qquad \text{(v)}$$

A term β is introduced for the neutralization of charges of micellized surfactant/IL by corresponding bounded counter-ions in the context of mono-ionic surfactants/ILs. Equation (v) then becomes

$$\Delta G_m^o = RTl(1+\beta)\ln_{CMC} \quad \text{(vi)}$$

The degree of micellization (α) and the counter-ion binding parameter (β) are related. Equation (vi) then changes to

$$\Delta G_m^o = RT(2-\alpha)\ln_{CMC} \quad \text{(vii)}$$

Enthalpy ΔH_m^o and entropy of micellization ΔS_m^o can alternatively be used to generate equation (vii) as

$$CMC = \exp\left[\frac{\Delta H_m^o}{(2-\alpha)RT}\right]\exp\left[\frac{-\Delta S_m^o}{(2-\alpha)R}\right] \quad \text{(viii)}$$

ΔH_m^o and ΔS_m^o can be determined by using CMC at various temperatures and the nonlinear least squares approach.

6. Applications of ILs throughout a wide range of fields

There are now a lot of ILs with long alkyl chains, and having them causes them to act differently. The hydrophobic nature of the lengthy alkyl chains in IL molecules causes them to cluster or form micelles. The main feature drawing attention to ILs is that, in comparison to cationic surfactants with identical structures, ILs form micelles or aggregates at low CAC/CMC levels. As a result, a wide range of applications that use the surface-active ionic liquid can grow, even in little amounts. Additionally, extensive research has been done to modify the self-assembling capabilities of SAILs in aqueous fluids and other solvents. ILs' ability to self-organize when exposed to various organic solvents and salts has a wide range of uses, including in the field of micellar liquid chromatography (MLC) [Armstrong and Henry, 1980].

Ionic liquids are used as reaction media in the production of energy, functional materials, eco-friendly composites, cellulose dissolving, addition, chromatography and electrochemical sensors. When water is used as a solute in the process of splitting it, ILs may function as solvents and electrolytes. Izgorodin *et al.* (2012) reported on the use of water splitting when protic ILs were present. In order to produce hydrogen peroxide from water, MacFarlane *et al*. (2014) reported using MnO in water splitting. Additionally, it is possible to strategically use ILs to improve the thermal stability, functionality and

security of numerous high-tech electrochemical devices [Shaplov *et al*., 2010]. Cellulose is one of the main constituents of wood and is characterized by having both intramolecular and intermolecular hydrogen bonding in wood industrial uses.

The fundamental element of its disintegration is this H-bonding. Numerous studies [Swatloski *et al*., 2002; Maki-Aruela *et al*., 2010] demonstrate that IL can act as a medium to dissolve the cellulose. ILs can be utilized to transform biomass into domestic fuels in the energy production sector [Wishart, 2009]. ILs were discovered to function as the electrolyte in dye-sensitized solar cells [Gorlov, 2008]. Additionally, ILs can be employed as materials that conduct heat and can generate power using thermoelectric methods. ILs can replace volatile organic solvents in the paint industry by offering better finishing, transparency, color stability, and resistance. ILs are discovered to be used as solvents and catalysts in the production of organic compounds.

Wishart (2009), Gorlov (2008) and Gratzel *et al*. (2003) demonstrate that enhanced selectivity also increases product yield. Due to the presence of silanol groups, silica gel is required as a support in thin-layer chromatography (TLC), and broadening of peaks is seen in separation analysis [Kaliszan, 1987]. ILs were discovered in the TLC study to lessen the silanol influence on drug retention. In contrast to polar solvents, ILs can preserve the stability and catalytic activity of enzymes [Park and Kazlauskas, 2003]. Numerous studies [Abdal-hay *et al*., 2017; Van and Sheldon, 2007; Yang and Pan, 2005] have described how IL medium is the preferred environment for enzyme-catalyzed biological processes.

7. Conclusion

The ILs can be employed as electrolytes for batteries, photovoltaic sensors, optical sensors, fuel cells, and electrochemical capacitors because of their improved electrical conductivity, inflammability, and thermal stabilities [Sato *et al*., 2004]. In addition to producing solid-state reference electrodes, ILs have been found to improve ion-detection sensitivity when utilized as a matrix in reference electrodes (Maminska *et al*., 2006; Kakiuchi *et al*., 2007). Finally, the uses for ILs go well beyond our wildest dreams.

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Chapter - 6
IC Engine Cooling System Augmentation using AI

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Chapter - 6

IC Engine Cooling System Augmentation using AI

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Abstract

Cooling system in an IC engine plays a vital role in regulating temperatures, dissipating heat, maintaining combustion efficiency, ensuring lubrication stability, controlling emissions, and preserving the engine's longevity. Without proper cooling, an engine's performance, reliability, and lifespan would be significantly compromised. Several advanced technologies are being used in cooling IC engines to enhance efficiency, performance, and environmental sustainability. Engine manufacturers and researchers continue to explore innovative approaches to improve cooling efficiency, optimize performance, and meet the demands of stricter environmental regulations. Advanced cooling systems incorporate variable flow control mechanisms that adjust the rate of coolant flow based on engine temperature and load conditions. This technology allows for more efficient cooling while reducing energy losses associated with excessive coolant circulation. Artificial intelligence (AI) plays a significant role in optimizing variable flow control mechanisms in IC engines. In this chapter, the role of AI in optimizing variable coolant flow control mechanisms by leveraging data analysis, predictive and adaptive control, optimization techniques and fault detection were discussed.

Keywords: AI Cooling, adaptive cooling, variable flow, coolant control

Introduction

IC engines generate a significant amount of heat during operation, and without an efficient cooling system the engine's components can overheat leading to various issues. Cooling system optimization is vital for maximizing the performance, efficiency and durability of IC engines, while also ensuring safe and environmentally friendly operation. The cooling system helps regulate the engine's temperature within an optimal range. It prevents overheating, which can cause engine damage, such as warping of cylinder heads, piston seizure, or even catastrophic failure. By maintaining the engine at the ideal operating temperature, the cooling system ensures efficient

combustion and reduces the risk of thermal stress on engine components. Proper cooling system optimization helps enhance engine performance and efficiency.

When the engine operates at an optimal temperature, it can achieve better fuel combustion, leading to improved power output and fuel efficiency. In contrast, an overheating engine may experience reduced power, increased fuel consumption, and higher emissions. Overheating can significantly impact the lifespan of engine components. Excessive heat can cause thermal expansion, leading to increased wear and tear on critical parts like pistons, cylinders, valves, and bearings. By keeping the engine temperature in check, the cooling system helps extend the life of these components, reducing the frequency of maintenance and repair. Engine cooling systems often play a role in cooling the engine oil as well. Efficient cooling helps maintain the oil's viscosity, ensuring it can effectively lubricate the engine's moving parts. Proper lubrication reduces friction and wear, enhancing the overall performance and durability of the engine. Cooling system optimization indirectly contributes to emission control. When an engine runs at the correct temperature, it allows the catalytic converter to operate optimally. The catalytic converter relies on the engine's exhaust gases reaching and maintaining a specific temperature range for efficient emission reduction. An inefficient cooling system can disrupt this balance, leading to increased emissions. Engine overheating can be dangerous, especially in extreme cases where it may result in engine fires. A well-functioning cooling system minimizes the risk of such incidents and helps ensure the safe operation of the vehicle or equipment.

IC engine cooling technologies

Engine manufacturers and researchers continue to explore innovative approaches to improve cooling efficiency, optimize performance, and meet the demands of stricter environmental regulations. The latest cooling technologies employed in modern IC engines are discussed in the following sections.

Variable Valve Timing (VVT): VVT technology allows the engine to adjust the timing of the intake and exhaust valves, optimizing the airflow into and out of the combustion chamber. By controlling valve timing, the engine can better regulate heat generation and cooling requirements, improving overall efficiency and reducing emissions.

Variable Valve Lift (VVL): Similar to VVT, VVL technology enables the engine to adjust the lift of the intake and exhaust valves. This capability enhances combustion control, optimizes airflow, and improves cooling efficiency by reducing pumping losses and promoting better air-fuel mixing.

Electric Water Pumps (EWPs): Electric water pumps are replacing traditional mechanical water pumps in some modern engines. They offer better control over coolant flow, allowing more precise regulation of engine temperature. EWPs are more efficient, consume less power and enable on-demand coolant flow, resulting in improved fuel economy.

Coolant flow control: Advanced cooling systems incorporate variable flow control mechanisms that adjust the rate of coolant flow based on engine temperature and load conditions. This technology allows for more efficient cooling while reducing energy losses associated with excessive coolant circulation.

Coolant direct injection: In certain high-performance engines, coolant direct injection systems are utilized. Instead of relying solely on air cooling or a conventional coolant jacket, these engines have small nozzles that directly spray coolant onto critical engine components, such as the pistons and cylinder walls. This targeted cooling approach provides efficient heat extraction from areas with high thermal loads, improving performance and durability.

Two-phase cooling: Two-phase cooling technology involves using a mixture of coolant and refrigerant to transfer heat from the engine. This approach utilizes the refrigerant's higher heat transfer capacity to enhance cooling efficiency. Two-phase cooling is particularly beneficial in high-performance and heavy-duty applications where conventional cooling methods may be insufficient.

Active grille shutters: Active grille shutters are becoming more prevalent in modern vehicles. They are designed to automatically open or close the grille to control the airflow entering the engine compartment. By regulating the amount of airflow, active grille shutters optimize cooling efficiency and reduce aerodynamic drag, contributing to improved fuel economy.

Advanced materials: The use of advanced materials with improved thermal conductivity and heat dissipation properties is another trend in cooling IC engines. For example, composite materials and ceramics are being employed in components such as cylinder heads and pistons to enhance heat transfer and reduce weight.

Variable coolant flow control mechanism in IC engines

Variable coolant flow control mechanisms in IC engines refer to the techniques and systems used to adjust and optimize the flow rate of coolant within the engine's cooling system. These mechanisms allow for dynamic

control of coolant flow based on various engine operating conditions, resulting in improved engine performance, enhanced thermal management, and increased overall efficiency. Thermostatic valves are commonly employed in cooling systems to regulate coolant flow. These valves open or close based on the engine's operating temperature, allowing coolant to flow through the engine when the temperature is high enough to require cooling. This mechanism ensures that coolant is circulated only when needed, optimizing energy consumption and reducing warm-up time. Advanced electronic control systems utilize sensors and actuators to modulate coolant flow based on real-time engine parameters. The engine control unit (ECU) monitors factors such as coolant temperature, engine load, speed, and operating conditions to determine the optimal coolant flow rate. Electronic valves or pumps can be used to adjust the flow rate accordingly, providing precise control and responsiveness.

Traditional fixed-speed coolant pumps are being replaced by variable speed pumps in modern engines. These pumps adjust their rotational speed based on engine requirements, allowing for the precise control of coolant flow. By operating at lower speeds when less coolant flow is needed, energy consumption is reduced, resulting in improved efficiency. Advanced cooling system designs incorporate variable geometry channels and fins within the engine block and cylinder head. These channels and fins can be modified to change the coolant flow path and enhance heat transfer efficiency. By adapting the cooling system's geometry based on engine operating conditions, temperature distribution can be optimized, resulting in improved cooling and reduced thermal stress. Some research focuses on utilizing active materials that can change their physical properties based on external stimuli. These materials can be integrated into the cooling system to control coolant flow. For example, shape memory alloys can actuate valves or other flow control elements to adjust coolant flow rates in response to temperature changes.

Role of AI in variable coolant flow control

AI plays a significant role in optimizing variable coolant flow control mechanisms in IC engines. AI algorithms can analyse large volumes of data collected from sensors, such as engine temperature, load, and coolant flow rate, to understand the complex relationships and patterns. By learning from this data, AI models can create accurate models of the engine's thermal behaviour and coolant flow dynamics. AI-based predictive control algorithms can use the models created to anticipate future changes in engine temperature and optimize the coolant flow accordingly. These algorithms can consider various factors, such as anticipated engine load, ambient conditions, and driver

behaviour, to dynamically adjust coolant flow rates in real-time. AI enables coolant flow control mechanisms to adapt and self-adjust based on changing conditions. AI algorithms can continuously monitor and analyse engine performance, temperature variations, and other relevant parameters. Based on this analysis, the AI system can dynamically optimize coolant flow rates to maintain the engine within the desired temperature range. AI algorithms can optimize coolant flow control mechanisms to maximize energy efficiency while ensuring effective cooling. By considering real-time operating conditions and constraints, AI can find the optimal coolant flow rates that minimize energy consumption while still providing sufficient cooling capacity. AI systems can continuously learn and adapt to evolving engine characteristics and operating conditions.

Through machine learning techniques, AI algorithms can update the models and control strategies based on new data, allowing the coolant flow control mechanisms to continuously improve their performance and efficiency over time. AI can also aid in detecting anomalies or faults in the cooling system. By analysing sensor data and comparing it to expected patterns, AI algorithms can identify potential issues such as coolant leaks, pump malfunctions, or clogged channels. This enables early detection and timely maintenance, preventing potential engine damage and improving reliability. AI algorithms can integrate with other vehicle systems, such as the powertrain management system, to optimize overall engine performance and efficiency. By coordinating coolant flow control with other parameters, such as throttle position, ignition timing, and fuel injection, AI can achieve synergistic effects and enhance the overall operation of the engine.

Engine coolant flow dynamics AI model

The specifics of creating an AI model for engine thermal behaviour and coolant flow dynamics can vary depending on the complexity of the engine, available data, and the specific goals of the application. Relevant data is collected from the engine and its sensors during various operating conditions. This data includes parameters such as engine speed, coolant temperature, ambient temperature, coolant flow rate, and other relevant variables. The data should cover a wide range of operating conditions to capture the engine's behaviour comprehensively. The collected data is pre-processed to remove noise, handle missing values, and normalize the variables if necessary. Feature engineering techniques are applied to extract relevant features that capture the engine's thermal behaviour and coolant flow dynamics. These features can include temperature differentials, rates of change, and correlations between variables. Depending on the complexity of the problem and the available data,

various machine learning models can be considered, such as regression models, neural networks, or decision trees. The choice of model depends on the specific requirements of the problem and the available computational resources.

The pre-processed data is split into training and validation sets. The model is trained on the training set by adjusting its parameters to minimize the difference between predicted and actual coolant flow rates or engine temperatures. This process involves iterative optimization techniques, such as gradient descent, to update the model's parameters. The trained model is evaluated using the validation set to assess its performance and generalization ability. Metrics such as mean squared error (MSE), root mean squared error (RMSE), or coefficient of determination (R-squared) are commonly used to evaluate the model's accuracy. Once the model demonstrates satisfactory performance, it can be deployed to make predictions in real-time. The model can be integrated into the engine's control system, enabling it to adjust coolant flow rates based on predicted engine temperatures. It is important to continuously monitor the model's performance and retrain it periodically using new data to maintain accuracy and adapt to changing operating conditions.

Coolant flow rate control optimization algorithm

The specific details of the optimization algorithm can vary depending on the engine design, control system architecture, and optimization objectives. Optimizing variable coolant flow control mechanisms in IC engines typically involves a control algorithm that adjusts coolant flow rates based on various engine parameters. The various steps involved a general algorithmic approach is as follows.

Define objectives: Clearly define the objectives of the optimization algorithm, such as maintaining the engine within a specific temperature range, maximizing energy efficiency, or minimizing emissions.

Collect data: Gather relevant engine data, including engine speed, coolant temperature, ambient temperature, load conditions and other parameters. This data serves as input for the optimization algorithm.

Determine control variables: Identify the coolant flow control variables that can be adjusted, such as coolant pump speed or valve position. These variables will be optimized by the algorithm to achieve the defined objectives.

Establish constraints: Define any constraints or limitations on the coolant flow control variables, such as minimum and maximum flow rates or physical limitations of the cooling system. These constraints ensure that the optimization remains within practical bounds.

Model development: Develop a mathematical or machine learning model that represents the relationship between the coolant flow control variables and the engine parameters. This model should capture the dynamics of the engine's thermal behaviour and coolant flow.

Objective function: Formulate an objective function that quantifies the optimization objectives. This function can incorporate multiple objectives, weighted according to their importance. For example, it could combine factors like engine temperature deviation, fuel consumption, and emissions.

Optimization algorithm: Choose an optimization algorithm, such as gradient-based methods, evolutionary algorithms, or reinforcement learning approaches, depending on the complexity of the problem and available computational resources. The algorithm iteratively adjusts the coolant flow control variables to find the optimal settings that minimize or maximize the objective function.

Simulation and Evaluation: Simulate the engine behaviour using the developed model and evaluate the objective function for each set of coolant flow control variables. The simulation should account for different operating conditions, such as varying loads or ambient temperatures, to ensure robustness of the optimization.

Optimization loop: Apply the optimization algorithm to iteratively update the coolant flow control variables. The algorithm adjusts the variables based on the gradient or search direction provided by the objective function evaluation. Repeat this loop until convergence or a predefined stopping criterion is met.

Implementation and Validation: Implement the optimized coolant flow control mechanism in the actual engine system. Monitor and validate the system's performance in real-time, comparing it with the simulated results to ensure consistency and effectiveness.

Continuous improvement: Continuously collect new data and retrain the optimization algorithm to adapt to changing operating conditions, system behaviour, or component degradation. This ensures that the coolant flow control mechanism remains optimized over time.

Creating a detailed algorithm flowchart for optimizing variable coolant flow control mechanisms in IC engines would require a more complex diagram. However, a high-level flowchart outlining the key steps involved in the optimization process is represented in figure-1.

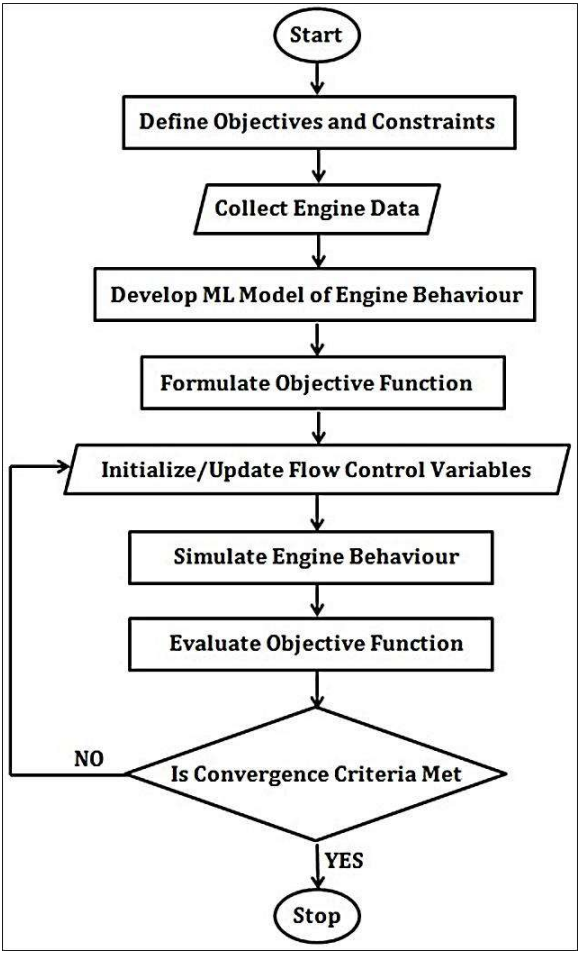

Fig 1: Flowchart for optimizing variable coolant flow

AI implementation cost for variable coolant flow control

The cost of implementing AI for variable coolant flow control mechanisms in IC engines can vary significantly depending on several factors, including the complexity of the system, the level of integration, the scope of data collection and analysis, and the specific AI techniques and algorithms employed. Developing and fine-tuning AI algorithms for coolant flow control can involve significant research and development costs. This includes data collection, modelling, algorithm design, and simulation. The cost will depend on the expertise and resources required for the development process. Implementing AI for coolant flow control may necessitate additional sensors and data infrastructure to collect relevant engine data. This could involve the

installation of temperature sensors, flow rate sensors, and other monitoring devices. The cost will depend on the number of sensors required, their quality, and the complexity of the data collection system. AI algorithms often require substantial computational power for training and real-time operation. The cost of implementing AI for coolant flow control includes acquiring or upgrading the necessary hardware, such as powerful processors or dedicated AI accelerators, to handle the computational demands of the algorithms.

Integrating the AI-based coolant flow control mechanism with the engine's existing control systems can involve costs related to software development, communication interfaces, and testing. Compatibility with the engine's control architecture and the complexity of the integration process will influence the overall cost. Rigorous testing and validation are necessary to ensure the reliability, robustness, and safety of the AI enabled coolant flow control system. This includes both virtual and physical testing scenarios, which may require specialized test equipment and facilities. The complexity and extent of the testing will impact the overall cost. On-going maintenance and updates of the AI system are essential to address evolving needs, improve performance, and ensure compatibility with new engine models or updates. The cost includes periodic model retraining, software updates, and monitoring to maintain optimal performance over time.

Concluding remarks

Major automotive manufacturers, such as BMW, General Motors, Toyota, Volkswagen, and Ford, invest heavily in research and development to enhance engine efficiency and performance. These companies often collaborate with research institutions and technology suppliers to develop innovative cooling systems and control algorithms that leverage AI and machine learning techniques. Additionally, technology companies specializing in automotive systems, such as Bosch, Continental and Delphi, work closely with automakers to develop advanced control systems and cooling solutions that incorporate AI algorithms for optimizing coolant flow control.

AI-based coolant flow control mechanisms can be integrated with other vehicle systems, such as the powertrain management system, to optimize overall engine performance. Coordinated control of coolant flow with other parameters, such as throttle position and fuel injection, can further enhance engine efficiency and response. While AI-based variable coolant flow control mechanisms offer numerous advantages, their implementation requires careful consideration of factors such as cost, data collection, model development, and

integration. Collaboration between automotive manufacturers, technology companies, and research institutions is crucial to drive innovation and maximize the benefits of AI in IC engine cooling. As the automotive industry continues to advance, it is likely that AI-based approaches will play an increasingly significant role in optimizing engine cooling systems, contributing to improved efficiency, performance, and environmental sustainability.

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Chapter - 7
Procrastination: A Systematic Review

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Chapter - 7

Procrastination: A Systematic Review

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Abstract

Procrastination is a widespread and global problem that is described as a voluntary, unreasonable delay of behaviour, with significant prevalence rates among students. Its widespread use among college students has major consequences for their mental health and well-being. In the present work, we have analysed the procrastination associated with academics, workplace, self-regulation, smartphone addiction, procrastination among different countries, bedtime, and trait procrastination. It is examined that systematic training of the emotional regulation skills can tolerate procrastination. Academic procrastination is a barrier to students' academic performance and outcomes, highlighting the necessity of developing and researching academic procrastination therapies as a means of lowering its prevalence in academic contexts. Procrastination is a detrimental habit that has a negative impact not just on students' academic achievement but also on workers' productivity. It prevents people from attaining their full potential, has a negative impact on their mental health, and can occasionally affect interpersonal relationships. The procrastination issue suggests that self-regulation strengthening measures could be used to avoid insufficient sleep. Due to the threats posed college students' mental health and career preparation have become significant objectives as a result of the epidemic of COVID-19. Students' learning has been hampered by online learning methods, which have resulted in stressful loads such as anxiety and depressive symptomatology. Not just undergraduate students, but also undergraduate professors/professionals, struggle with procrastination. Achievement, Independence, Recognition, Relationship, work, and support at workplace are job characteristics that lead to procrastination. It is a purposeful course of conduct, regardless of the negative consequences.

Keywords: Procrastination, COVID-19, academic performance, career planning, self-regulation, emotional regulation skills

Introduction

Procrastination is defined as the deliberate, unreasonable delaying of an intended course of action despite understanding that doing so will cost the individual money or have undesirable consequences (Simpson & Pychyl, 2009). Chronic procrastination is defined as the proclivity to delay in a range of scenarios that appear to be vital for achieving goals (Díaz-Morales *et al*., 2008).

Procrastination is a sort of self-control failure characterised by the deliberate postponing of desired responsibilities (Chen & Qu, 2017). Trait procrastination is the tendency to put off completing what needs to be done in order to achieve a goal (Stead *et al*., 2010). The Calculated, Procrastination is defined as the deliberate deferral of a planned course of action past the period when it is most likely to result in the desired outcome (Wohl *et al*., 2010). Procrastination is the inclination to put off doing what is required to achieve a goal (Profile, 2011).

Academic procrastination is most commonly evident in tasks that students are expected to complete, such as studying for exams, doing assignments, or postponing a meeting or project with an academic consultant (Mandap, 2016).

The lack of intention or willingness to act is referred to as procrastination (Yilmaz, 2017). Academic assignments and daily activities are hampered by procrastination, which has been recognized as a prevalent issue (Ziegler & Opdenakker, 2018). Procrastinate is a self-handicapping or purposeful self-motivating method in which students withdraw their effort when faced with difficult tasks or procrastination in doing school activities (Ng, 2016).

Procrastination is the deliberate delaying of a course of action, either at the start or at the end (Klingsieck *et al*., 2012). Procrastination is a well-known phenomenon that refers to the voluntary delay of work that should be completed right away, despite the fact that doing so may have negative consequences (Eckert *et al*., 2016).

Procrastination is a well-known phenomenon that refers to the voluntary postponing of tasks that should be accomplished despite the fact that the postponement may have negative consequences (Klassen *et al*., 2010). The tendency to procrastinate is frequently linked to a lack of self-control mechanisms. Several studies have looked at "self" variables like self-handicapping (Michinov *et al*., 2011).

According to the theory, not all postponing behaviours are bad or have negative consequences. the necessity to revise postponing behaviour’s

repercussions for individual outcomes as we get a more nuanced grasp of it (Angela Hsin Chun Chu & Jin Nam Choi, 2005). The number of siblings, the grade level, and the extent of underachievement are all factors to consider, this study's intriguing "sibling effect" on procrastination could be attributed to and mediated by these group level characteristics (Rosário *et al*., 2009).

Literature Review

Academic

Procrastination

A study of high school, undergraduates, and graduates found that undergraduates procrastinate more than graduates, who procrastinate more than high school students (Ozer, 2011). Participants with higher degrees of procrastination reported better levels of life satisfaction, according to the study. The findings in this regard revealed that procrastination causes unpleasant feelings in students (Profile, 2011). According to a study, procrastination is more common in male students than female students due to a hatred of activities and the perceived difficulty of completing a work. Students with poor academic self-efficacy take longer to finish assignments than students with high academic self-efficacy, according to research (Mandap, 2016).

The fact that high procrastinators started later and worked less than the low procrastinators there is no significant difference in both the student groups (Yilmaz, 2017). According to a study, active procrastinators are more likely to abandon and fail to complete activities, whereas passive procrastinators are more likely to abandon and fail to finish undertakings (Ng, 2016). Procrastination has a negative impact on a person's job as well as emotions of guilt, inadequacy, self-disgust, tension, and melancholy (Takács, 2005).

A study was conducted on a unique algorithm for automatic assessment of students' performance through procrastinating behaviours (called PPP). With a large percent accuracy rate, PPP was able to predict students' performance based on their procrastinating habits (Hooshyar & Pedaste, 2020).

Academic procrastination is most commonly evident in tasks that students are expected to complete, such as studying for exams, doing assignments, or postponing a meeting or project with an academic consultant (Kandemir, 2014). Students were asked to complete a list of study skill habits, such as "I practice self-testing" and "Before every lecture, I prepare by becoming familiar with the material." It was observed that students who scored low on

the SSH scale were more likely to procrastinate academically (Svartdal *et al*., 2021).

Two separate learning settings were set up for the course in which the study was conducted: face-to-face and distant learning. The negative link between academic procrastination behaviours and assignment performance of procrastinating students in the Distance Learning group is larger than the relationship observed in the Face to Face group, according to the data (Yilmaz, 2017).

Procrastination was stated most frequently by students when writing term papers or their thesis, as well as when studying for exams (Grunschel *et al*., 2013). In undergraduates, general procrastination was positively connected with perceived stress, whereas self-compassion was negatively correlated, indicating that testing of procrastination's indirect effects on stress via self-compassion was suitable (Sirois, 2014). Academic Procrastination is a barrier to student's academic performance and outcomes, highlighting the necessity of developing and researching academic procrastination therapies as a means of lowering its prevalence in academic contexts (Goroshit, 2018).

The "acceptance-involvement" and "psychological autonomy-granting" parenting styles were substantial and negative predictors of academic procrastination, whereas the "behavioural strictness-supervision" style had considerable predict power for academic procrastination. (Zakeri, HamidrezaZakeri, H., Esfahani, B. N., & Razmjoee, M. (2013).

According to the findings, self-efficacy moderated the effects of instructor organization/support and course situational interest on procrastination, while task value moderated the effects of instructor organization/support and course situational interest on procrastination (Corkin *et al*., 2014). Students who are well-organized and strive for high personal objectives are less likely to procrastinate when it comes to studying, writing papers, or completing reading tasks (Burnam *et al*., 2014). Students who are organised and strive for high personal standards are less likely to procrastinate when studying, writing papers, and completing reading assignments, and they are also less likely to suffer from procrastination (Kljajic & Gaudreau, 2018).

Procrastination is more than a poor habit or a lack of motivation. Chronic, pervasive procrastination is a maladaptive behaviour that can have major negative repercussions if it is continued throughout one's life, depending on the behaviours or acts one chooses to put off forever (Ferrari & Roster, 2018). Procrastination was the socially dictated perfectionism dimension most closely connected with both generalised and academic procrastination,

particularly among males, according to correlational analyses (Flett *et al*., 2006).

There is diversity in the development of procrastination on a class and student level. Previous research on class and student discrepancies, as well as a generalised negative trend in math engagement at the class and school level, found substantially larger heterogeneity on a student level in their study on math engagement development, corroborated these findings (Ziegler & Opdenakker, 2018).

Procrastination is a common but dysfunctional phenomenon among students (Häfner *et al*., 2014). According to bivariate correlations, the mastery-approach goal orientation is inversely connected to procrastination, whereas the mastery-avoidance goal orientation is positively related (Howell & Watson, 2007).

Undergraduate students and undergraduate teachers are both affected by procrastination, and the effects of student procrastination on academic performance is a widespread concern (Jones & Blankenship, 2021).

The interaction of self-regulation and procrastination

Negative procrastination has negative implications, and negative procrastinators reported greater time spent procrastinating, worse levels of self-efficacy for self-regulated learning, and reduced general procrastination in Canada and Singapore (for Canadians) (Klassen *et al*., 2010).

The motivation & academic self-efficacy did not have a direct impact on academic performance**.** Study examined on undergraduates and graduates' students who enrolled for online courses. The findings supported that graduate students would have more adaptive self-regulated learning profiles than undergraduates (Rajapakshe, 2021). On the one hand, there are definitional parallels between active procrastination and arousal delay in terms of deferring activities closer to deadlines in order to boost desire to work without experiencing negative consequences (Chowdhury & Pychyl, 2018).

The ability to distinguish the time course of mistake and sensory processing in procrastination, as well as the moment at which certain impulsivity-related cognitive deficiencies become apparent, is enabled by temporal sensitivity (Michalowski *et al*., 2020).

Bed-time Procrastination

The fact that going to bed late is a procrastination issue suggests that self-regulation strengthening measures could be used to avoid or reduce insufficient sleep. Implementations intentions, for example could be

particularly in this situation because they do not necessitate the use of cognitive resources (Kroese *et al*., 2014).

Trait Procrastination

Neuroticism and Extraversion are reliably related to the primary qualities of why do we postpone, and what activities do we choose when we procrastinate? Those with a high level of neuroticism report deferring activities due to anxiety, while those with a low level of neuroticism show little concern or fear. Those with a high extraversion score said they were put off by social reasons, while those with a low score said they were put off by a lack of energy or a desire for seclusion (Steel & Klingsieck, 2016).

When it came to avoiding scholastic tasks, Canadians preferred obtaining something to eat or drink. When it came to avoiding scholastic tasks, students favoured taking a nap. It was acknowledged that Canadian students see procrastination as having a negative impact less than Singaporean students (Klassen *et al*., 2010).

According to the studies in Journal of Rational-Emotive and Cognitive-Behaviour Therapy Procrastinators had greater levels of maladaptive thinking in four categories: frustration intolerance, self-depreciation, and self-depreciation ideas (Pychyl & Flett, 2012). Procrastination is a trait behaviour that causes one to postpone completing a task (Mohsin & Ayub, 2014). Procrastination at work research has primarily focused on the implications for the procrastinator, finding detrimental effects on job performance and subjective well-being (Legood *et al*., 2018).

Procrastination is a widespread disorder characterised by problems with self-control, especially deferring the start and completion of crucial tasks (Aftab *et al*., 2017). When they voluntarily postpone ending up initiated transactions, online procrastinators favour pressure. They also prioritise duties appropriately and successfully execute transactions at the last minute. They purposefully delay decisions in order to maximise their chances of getting the best deal (Negra & Mzoughi, 2012).

Procrastination and the impact of smartphone addiction

Result of night time procrastination, the indirect positive effects of self-regulation on all three sleep quality metrics were shown to be significant. People who have trouble with self-control or regulation are more prone to procrastinate (Xuan & Wu, 2020).

Low trait self-control, frequent Facebook checking, and high Facebook enjoyment all predict a significant amount of variance, according to studies.

They also show that using Facebook to irrationally delay key tasks raises students' academic stress levels (Meier *et al*., 2016). The findings revealed that effective, research-based care is possible. Procrastination could be a low-cost, low-threshold strategy to help the enormous number of students who are having problems as a result of their procrastination habits (Küchler *et al*., 2019)

Procrastination among different countries

Procrastination was studied in Israel among well-educated persons. The findings demonstrated that procrastination in the financial, education and career life-domains was moderately associated with procrastination in other life-domains, and that procrastination in other life-domains was moderately associated with procrastination in other life-domains on a weekly basis (Hen & Goroshit, 2018). After adjusting for the two cognitive schemas, the results in the US population indicated a non-significant direct link between procrastination and depression, suggesting that the schemas entirely mediated the model. The two cognitive schemas produced a substantial direct and indirect effect in the Pakistani model, showing partial mediation (Aftab *et al*., 2017). In China, but not in the United Kingdom, self-regulation reduced the link between procrastination and life happiness. According to a study Procrastination did not indicate poorer levels of life satisfaction among Chinese students with higher levels of self-regulation (Yang, 2021). Despite the negative consequences, procrastination is a deliberate course of action (Ferrari & Roster, 2018).

Reducing procrastination

In one study, cross-sectional analysis revealed a connection between emotional regulation abilities and procrastination, which was mediated by the ability to tolerate painful emotions. Cross-lagged panel analyses in a second study revealed that the ability to modify aversive emotions reduced subsequent procrastination. Finally, a third study found that systemic training of emotional regulation abilities can help people accept procrastination. To overcome procrastination, emotion-focused solutions should be considered (Eckert *et al*., 2016).

In terms of minimizing procrastination, because each dimension does not equate to more timely task completion, the accomplishment status between the dimensions of exploration and commitment, as well as associated ego functions, is mixed (Shanahan & Pychyl, 2007).

The control group demonstrated procrastination by spending more time on a self-selected, important academic task in the weeks leading up to the

deadline than they had in the previous weeks. The treatment group, on the other hand, evenly distributed their work time and did not procrastinate. As a result, the time management intervention under investigation prevents a significant time management issue (Häfner *et al*., 2014).

Procrastination is a harmful behaviour that not only has a negative impact on students' academic performance, but also on the productivity of those who work. It keeps people from reaching their full potential, has a negative impact on their mental health, and can sometimes be harmful to their interpersonal relationships (Fernie *et al*., 2017). The importance of procrastination's impact on the well-being of a significant portion of the population, and it was thrilling to try to assist them and to pioneer work in the region, The therapies were then found to be successful in permanently reducing procrastination (Otermin-Cristeta & Hautzinger, 2018).

A flipped classroom design helps alleviate academic procrastination. The crucial motivational aspect helps the student to progressively recognise that quality home preparation will help him or her succeed in the topic, and the concept of the flipped class provides support in his or her study efforts (J. Hong *et al*., 2020).

COVID-19 and Procrastination

Employees who worked from home during the pandemic discovered that social support was positively associated with fewer remote working challenges; Job autonomy was shown to be adversely related to loneliness; workload and monitoring were both linked to higher work-home interference; and workload was also linked to lesser procrastination (Wang *et al*., 2021). They determine the disease's vulnerability and danger, as well as its transmission rates and regions. Family structures and interaction patterns, occupational behaviour, urban density, housing occupancy and overcrowding, workplace and retail environment structures and organisation and local social, economic and political conditions and cultural variety are among them. (Aronson *et al*., 2021)

Many students chose online learning during the lockdown; nevertheless, the findings revealed that those with High levels of academic procrastination were associated with low levels of self-regulated online learning, resulting in a strong judgement of the ineffectiveness of online learning (J.C. Hong *et al*., 2021). Because of the global spread of the novel coronavirus, many institutions resorted to online teaching and learning methods in order to save the academic year. This rapid change in teaching technique has impeded student learning and resulted in stressful loads among undergraduate students,

including anxiety and depressive symptomatology (Fawaz & Samaha, 2021). Individuals who score high on decisional procrastination have a higher impact on the planning prompt than those who score low. Decisional procrastination moderates the unfavourable relationship (Upadhye *et al*., 2021). Although remote learning, especially emergency distance learning in a crisis like COVID-19, can be challenging for students, instructors, and parents, SRL skills and a strong inner desire to learn may work as protective factors, encouraging not just academic achievement but also student well-being (Pelikan *et al*., 2021). Anxiety caused by the Coronavirus has been a major factor in young adults' career planning and decisions (Gray *et al*., 2021).

Participants with a high degree of academic procrastination had a low level of self-regulatory online learning, resulting in a high assessment of ineffectiveness of online learning (Aronson *et al*., 2021). Mindfulness techniques, introspection, and maintaining a gratitude journal were used in a study to assist people reduce procrastination (Ananya *et al*., 2013).

Impact of procrastination at workplace

Procrastination effect employee rather than the employers in the work place. Achievement, Independence, Recognition, Relationship, work, support & work place are job characteristics that lead to procrastination. Results shown that the high occupational procrastinators are Food servers & library assistants; Moderate procrastinators are Lawyers and educational teachers; low procrastinators are chief executives & economists (Nguyen *et al*., 2013).

Methodology

The literature search was limited to articles published from 2005-2021. The search for articles was done online by using the search words ‘’Academic procrastination, Work place, Trait procrastination, Pandemic effect on procrastination ‘’in the title and keywords in research databases at Wiley, Elsevier, Taylor & Francis, ERIC, Springer, SAGE, Frontiers.

Analysis

The method used is the Preferred Reporting Item for Systemic Reviews and Meta analytic (PRISMA) method. All articles that have passed the selection process were then reviewed and summarised based on the objectives, year of publication, number of citations and suggestions for further research.

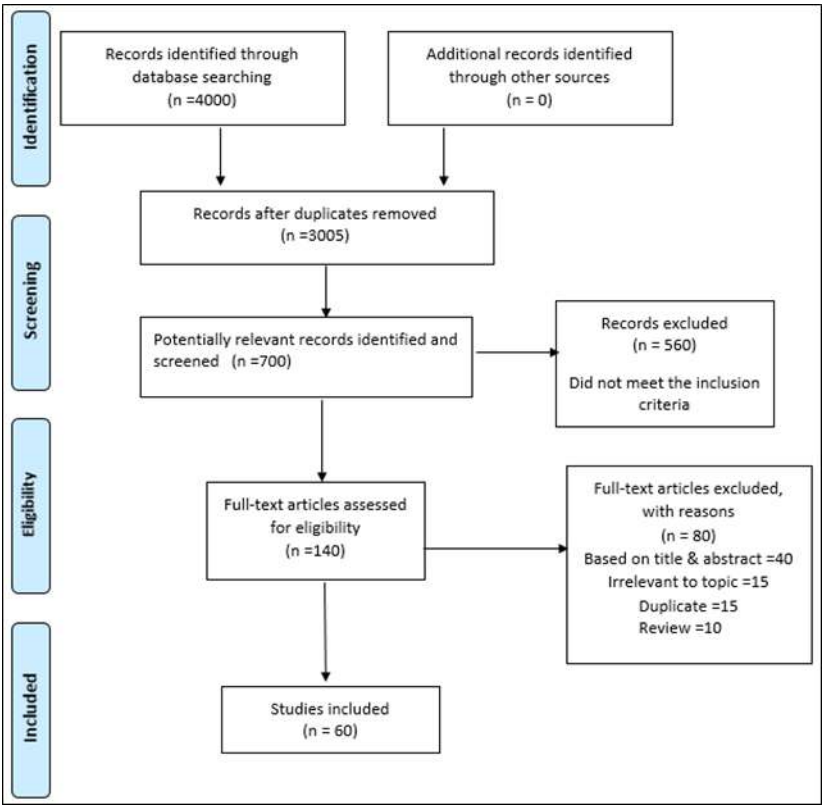
Inclusion & Exclusion criteria

The be included in current study, studies have to meet some criteria:

a) Studies have included some kind of selection criteria (Academic procrastination, work place). These criteria limited the number of studies.

b) Accordingly excluded the studies in which it based on irrelevant information there is no proper Title, Abstract & Review.

PRISMA flow diagram



Final data set

The research database search resulted in all keywords search results obtained 4000 research articles. After scanning the title, there was the same article in two different databases. The results after deducting the duplicates are 3005 articles. A total of 700 articles were screened. 560 Articles excluded that they did not meet the inclusion criteria.

Articles accessed for eligibility are 140 articles. A Total number of 80 articles were excluded based on title and abstract (40) Irrelevant to topic (15) Duplicate (15).

The final data set consists of 60 articles. The oldest included study was published in the year 2005 and the most recent study was conducted on 2021.

Discussion

Procrastination is the act of delaying making decisions or taking actions that are necessary to achieve goals. Students are notorious for procrastinating. Academic procrastination is particularly visible in tasks that students are required to do, such as studying for tests, completing assignments or postponing an appointment or project with an academic consultant. The study analyzed those higher degrees of Procrastination were associated with higher levels of life satisfaction. The current research looked at the impact of procrastination on student performance as well as ways to prevent procrastination through time management. Different types of procrastination were discussed like Trait procrastination, bedtime procrastination. According to studies, people who spend more time on their phones unjustly delay crucial activities, which increases students' academic stress levels. During the SARS-CoV-2 (coronavirus lockdown), the number of students attending online courses increased. Students' study hours are decreasing, while academic procrastination is increasing. Students who learn online from home are more likely to procrastinate because they must not only exercise greater self-control to overcome isolated learning but also avoid distractions at home. When these studies were combined, they revealed that procrastination was higher than typical during the outbreak. Participants with high levels of academic procrastination showed low levels of self-regulatory online learning, resulting in a high assessment of the ineffectiveness of online learning. Furthermore, our results revealed that sudden changes brought about by covid 19 played a part in encouraging procrastination.

Conclusion

In the light of the analysis, the researchers have drawn the following conclusions:

Students appeared to procrastinate and were unable to finish their work on time due to a lack of guidance and motivation leading them to prolong their academic work. Procrastination has a severe impact on students' learning, resulting in low exam scores, depression, and anxiety. The students were forced to stick to online learning by covid 19. Students learning has been hampered by this rapid shift in teaching techniques, which has resulted in high stress levels among students.

The provision of correct direction, appreciation, and positive comments on students' performance are some of the remedial strategies for controlling or minimising procrastination.

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Chapter - 8
Genomics Assisted Improvement of Direct Seeded Rice Variety for Herbicide Tolerance

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Chapter - 8

Genomics Assisted Improvement of Direct Seeded Rice Variety for Herbicide Tolerance

Manasani Prashanth, Mondem Bhargavi and Harisha T

Abstract

Rice is one of the most important food crops on the planet. It is accounted for that almost 30% of water expected for rice development is used in puddling alone. This requires a change in development practice from transplanting to direct seeded rice (DSR). In any case, weed pervasion is a significant requirement for effective rice cultivation under DSR which can cause yield loss of 50-91%. Lately, there are colossal advances in the examination and use of herbicide resistant genes in rice around the world. Different working systems are associated with the activity of six herbicide classes (glyphosate, glufosinate, acetolactate synthase inhibitor herbicides, hydroxyhenyl pyruvate dioxygenase (HPPD) inhibitor herbicides and dinitroaniline herbicides), transformations of the comparing herbicide-target genes prompts protection from herbicides and the herbicide detoxification components by non-target genes. The functioning systems behind the non-target safe genes are clarified (Glyphosate corrupting catalysts, N-acetyl transferase and cytochrome P450S). There is enormous genetic variation for resistance to herbicide exists among different crops, for example, maize, wheat, rice, sunflower, soybean, chickpea, alfalfa etc. Herbicide resilience in germ plasm or in mutant lines might be because of changed restricting site of target chemical for herbicide, further developed herbicide digestion, sequestration of herbicide atom and over expression of target protein.

Keyword: Direct seeded rice, herbicide tolerance, mutation, genes

Introduction

Rice (*Oryza sativa* L.) is the main grain that nourishes and nourishes more than half of the world's population and about 95% of the world's rice crops are used for human consumption. The Asian continent is the largest rice producer and consumer of rice. This is the staple food of about 60% of the world's population. Rice is grown in flood-prone ecosystems of irrigated rainwater

(lowlands and highlands). The main methods of rice cultivation in irrigation ecology are rice puddling and transplanting. It is reported that about 30% of the water required for rice cultivation is used only for puddling (Hasan *et al*., 2020). Due to the depletion of water resources and the shortage of agricultural labor, alternative rice cultivation is essential. This requires changing the practice of planting transplanted rice with seedless rice (DSR).

DSR is a potential alternative technology for sustainable rice farming, as it can save water up to 35-54%, labour up to 11-66%, reduces methane emission and increases net profit to farmers (Chakraborty *et al*., 2017). In the context of climate change, global warming, scarcity of labour and water, uncertainty of rainfall, the DSR is gaining popularity and replacing transplanting method of rice cultivation in India. Nearly 10% of total rice cultivation is considered to be under DSR condition in India. However, weed outbreaks are a major obstacle to successful rice production under DSR and can result in yield losses of 50-91%. Due to labor restrictions, manual weeding and cultivation practices for weed control are difficult to implement. Indeed, the application of herbicides is essential for effective control of weeds.

In India, weed control accounts for up to 30% of the total cost of rice cultivation. (Rao *et al*., 2015). Effective weed control has shown that DSR yields are roughly comparable to transplanted rice (Pathak *et al*., 2011). The use of herbicides is the most effective and economical option for weed control, but the selectivity of chemicals limits their use in crops such as rice. Therefore, the development of herbicide-resistant rice is essential to broaden the range of herbicide resistance. Safe and effective herbicides should be used in minimal doses to ensure environmental safety.

The significant advantages of herbicide tolerant rice are control of more extensive range of weeds, diminished crop injury, decreased herbicide persist, utilization of herbicides that are more ecological agreeable, new method of activity for obstruction the board and harvest the executives adaptability and effortlessness. Basically, herbicides work by interfering with major chemicals or proteins involved in the basic metabolic or physiological cycles involved in plant development and progression. Some herbicide-tolerant crops were produced by showing transformation at the target site of herbicide activity, while others showed genes that detoxify herbicide atoms. Both of the above systems have been used to generate herbicide-tolerant (HT) transgenic plants, but previous methodologies have also been achieved by mutagenesis (non-GM approach). Non-GMOHT crops enjoy the benefits of easy registration or supply for business development and broader public awareness (Tan *et al*., 2005).

The issue of weeds (particularly weedy rice) in rice cultivation can be settled by the utilization of herbicide-safe rice in mix with relating herbicides. As a result, herbicide-safe rice is gaining more and more attention and has become a major topic in genetic breeding. Artificial mutagenesis and mutagenesis, site-specific mutagenesis of herbicide resistance genes, or introduction of exogenous resistance genes into rice by transformation has yielded safe rice strains for a variety of herbicides. Herbicide-tolerant crops (HTCs) have been commercially developed since 1984 with the announcement of the first triazine safe variety (OAC Triton) to attack oil seeds in the Canadian market. This strain was created using traditional breeding techniques. The triazine resistance of *Brassica rapa* L. was backcrossed to commercial rapeseed varieties for herbicide resistance.

Major herbicides and their corresponding target genes

Imidazolinone and AHAS (Aceto Hydroxy Acid Synthase)

Imidazolinone herbicides control weeds by repressing the chemical aceto hydroxy acid synthase (AHAS), additionally called acetolactate synthase (ALS), which is a basic compound for the biosynthesis of branched chain amino acids in plants. These herbicides control a wide range of grass and broadleaf weeds, are viable at low application rates, have low mammalian harmfulness and have a great natural profile. In this way imidazolinone herbicides have numerous ideal qualities for use in a herbicide resistant crops. Moreover, imidazolinone tolerant plants with modified AHAS genes and catalysts have been found in many yields. This makes it possible to develop imidazolinone-tolerant crops based on the resistance mechanism at the site of action for these crops. Imidazolinones are among the five synthetic groups of AHAS-inhibiting herbicides. The other four families are sulfonylureas, triazolopyrimidines, pyrimidinyl thiobenzoates and sulfonylamino-carbonyltriazolinones. Imidazolinones includes imazapyr, imazapic, imazethapyr, imazamox and imazaquin. As the names show, all imidazolinones have an imidazole moiety in their molecular structure. They are additionally partitioned into three groups in light of the second cyclic design of their particles excluding the imidazole ring. Imazaquin has a quinoline moiety, imazamethabenz has a benzene ring and the other imidazolinones have a pyridine ring.

Interaction between imidazolinone herbicides and the AHAS enzyme

Analysis of crystal structure of yeast AHAS and different investigations propose that the AHAS protein of eukaryotes might be made out of a catalytic sub-unit and a regulatory sub-unit. The catalytic sub-unit is in all likelihood a

homodimer shaped by the collapsing of two large sub-units (LSU); each LSU is a monomer of an AHAS polypeptide and has three areas of comparative size, α, β and γ. The regulatory sub-unit is accepted to be an AHAS small sub-unit (SSU) in eukaryotes.

A putative regulatory AHAS SSU has been cloned and communicated in a few plant Species. In view of sub-atomic demonstrating of AHAS-imidazolinone connection, the limiting pocket has been proposed to be at the passage site for the substrate of the AHAS enzyme. Results from the herbicide docking model, in combination with crystal structure analysis of the AHAS, propose that the two sulfonylureas and imidazolinones may tie in the substrate access channel and hinder the binding of the substrate to AHAS (Tan *et al*., 2005).

AHAS gene mutation and imidazolinone-tolerance trait

The greater part of the imidazolinone tolerant mutations come from amino acid replacements in areas α and γ. The most generally happening mutations that present resistance from AHAS inhibitors are at places of Ala122, Pro197, Ala205, Trp574, and Ser653 of the AHAS LSU (Fig.1). Most of popularized imidazolinone tolearant crops are as of now evolved from possibly one or a mix of Ala205, Trp574 and Ser653 mutations. Imidazolinone herbicide tolerant varieties are popularized in crops like wheat, rice, maize, rapeseed and sunflower.

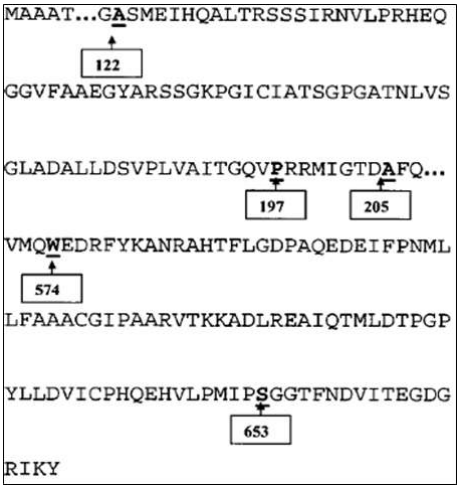

Fig 1: Partial amino acid sequence of Arabidopsis thaliana AHAS protein showing five amino-acids which are normally substituted from mutations in plants. The replacement gives protection from AHAS-repressing herbicides (Tan *et al*., 2005)

Glyphosate and EPSPS (5-enolpyruvoylshikimate-3-phosphate synthase)

Glyphosate is a phosphate compound with a stable Carbon-Phusphorous bond and it targets the 5-enolpyruvoylshikimate-3-phosphate synthase (EPSPS) in plant. EPSPS is a chloroplast enzyme that catalyzes the production of 5-enolpyrvir simimate triphosphate (EPSP) from phosphoenolpyruvate (PEP) and sychimate triphosphate (S3P). This is an important step in the synthesis of aromatic amino acids such as tryptophan, tyrosine and phenylalanine, as well as hormones, flavonoids, lignins, ubiquinones and other phenolic compounds. Glyphosate forms a stable EPSPSS3P-glyphosate complex with plant EPSPS. This conflicts with PEP, which interferes with EPSPS activity. As a result, the synthesis of aromatic amino acids required for protein biosynthesis is inhibited, shikimic acid is excessively accumulated, and the synthesis of hormones and secondary metabolites required for plant growth is also inhibited. These in turn cause impaired plant growth and metabolism, leading to plant death. Currently, 50 different weed species with different degrees of resistance to glyphosate have been found worldwide, of which 15 are resistant to glyphosate due to EPSPS mutations. The Thr102 and Pro106 mutated amino acids, Thr102 to Ile conversion and Pro106 to Ser conversion provide the highest levels of resistance to glyphosate (Fartyal *et al*., 2018).

Acetolactate synthase (ALS) inhibitor herbicides and ALS

ALS inhibitor herbicides kill weeds by inhibiting ALS. ALS is an important enzyme in the synthesis of branched-chain amino acids in plants such as valine, leucine and isoleucine. This group of herbicides inhibits the activity of ALS and prevents the synthesis of branched chain amino acids in plants. This interferes with protein synthesis, cell division, and plant growth, eventually leading to the death of the plant. Currently, the widely used ALS inhibitor herbicides include imidazolinones (IMI), sulfonylureas (SU), triazolo pyrimidines (TP), pyrimidinyl thio benzoates (PTB) and sulfonylamino-carbonyl-triazolinones (SCT).

Many studies on resistant weeds have shown that some weeds are resistant by increasing the detoxifying capacity of herbicides, but in most cases mutations in the ALS target gene are the major cause of herbicide resistance. Currently, a total of 66 different weed species develop resistance to ALS inhibitor herbicides through mutations in ALS. These include Ala122 (5), Pro197 (11), Trp574 (4), Ser653 (3), Ala205 (2), Asp376 (1), Arg377 (1), and Gly654 (2). Among them, Pro197 can be substituted by 11 other amino acids, including Threonine, Alanine, Arginine, Aspargine, Glutamine, Histidine, Isoleucine, Leucine, Serine and Tyrosine. Amino acid mutations in

ALS can change the enzyme structure or spatial conformation, reducing the protein affinity for herbicides and thus developing resistance. Different mutation sites and the types of substituted amino acids determine the level of resistance and the range of resistance to ALS inhibitor herbicides.

Glufosinate and glutamine synthetase

Glufosinate (phosphinotricine, PPT) is a non-selective, broad-spectrum herbicide that targets the nitrogen metabolism of plants, including the major enzyme glutamine synthetase (GS). GS converts glutamic acid and ammonia to glutamine. As an analog of glutamate, PPT competes with the natural substrate of GS, inhibits nitrogen assimilation and causes plants to accumulate excess ammonia, thereby reducing photosynthetic activity, disrupting chloroplast structure and glyoxylic acid. Causes decomposition and eventually death of the plant.

The emergence of glufosinate-tolerant plants is very late, and so far only one goosegrass and three ryegrass with some resistance to glufosinate have been identified. Studies of resistant Italian ryegrass have shown that the use of asparagine instead of aspartic acid 171 may be one of the reasons for the reduced sensitivity of GS to glufosinate due to changes in amino acid polarity (Garcia *et al*., 2012). The mutant rice glutamine synthetase (OsGS1; 1), which contains glycine at position 59 and arginine at position 296, has improved resistance to glufosinate (Deng *et al*., 2019).

Hydroxy phenyl pyruvate dixygenase (HPPD) inhibtor herbicides and HPPD

HPPD exists widely in a variety of organisms, and it catalyzes the conversion of hydroxyl phenylpyruvic acid (HPPA) into homogentisic acid (HGA), which is the precursor for the biosynthesis of plastoquinone and tocopherol in plant (Morgan, 2005). HPPD Inhibitors Herbicides chelate with Fe2 + at the active site of the enzyme, blocking the binding of HPPD to the substrate HPPA and causing competitive inhibition of HPPD. Plastoquinone and tocopherol are important precursors of carotenoid biosynthesis. Carotenoids play an important role in photosynthesis. Inhibition of HPPD blocks photosynthetic electron transfer, causing plant fading and death.

The rice gene HIS1 (HPPD inhibitor susceptibility 1) confer resistance to benzobicyclone (BBC) and other butrichtone herbicides. HIS1 encodes a Fe2 +/2 oxoglutaric acid-dependent oxygenase, which catalyzes the hydroxylation of the herbicide to detoxify the herbicide. Rice varieties sensitive to HPPD inhibitors and herbicides have a 28 bp deletion of the HIS1 coding region (Maeda *et al*., 2019).

Dinitroaniline herbicides and tubulin genes

Dinitroaniline herbicides are widely used for soybean and cotton weeding. Not only annual grass weeds but also annual broad-leaved weeds can be controlled. Dinitroaniline herbicides such as trifluralin, pendimethalin, and etalfluralin can bind to tubulin, interfere with microtubule polymerization, stop cell division and elongation, and kill plants (Chu *et al*., 2018). Molecular structural modeling and analysis of tubulin resistance mutations in plants shows that dinitroaniline is most likely to interact with tubulin and interfere with microtubule polymerization.

Working mechanisms behind non target herbicide resistant genes

Glyphosate degrading enzymes

Recent studies have shown that soil microorganisms such as bacteria, actinomycetes and fungi can degrade glyphosate. From these microorganisms, scientists have isolated many genes that confer resistance to glyphosate. igrA (increased glyphosate resistance A) cleaves the CP binding of glyphosate to produce sarcosine and inorganic phosphorus. Glyphosate n-acetyl transferase (GAT) transfers the carboxyl group from CoA to the N-terminus of glyphosate to produce n-acetyl glyphosate, a non-toxic herbicide product (Green *et al*., 2008).

N-acetyltransferase

N-acetyltransferase (phosphinotricine acetyltransferase, PAT) can acetylate toxic LPPT and thereby detoxify glufosinate. Balthazor and Terry (1987) clone the streptomyces hygroscopicus bialaphos resistance gene (bar) or the Streptomyces viridochromo phosphinotricine acetyltransferase gene (pat) to confer glufosinate resistance. With advances in microbial genome sequencing, nucleotide sequences encoding PAT family proteins have been predicted in many microorganisms, but those that have been identified as glufosinate resistant or used in commercialized transgenic plants there is none. Currently, only bars and putts are used for marketing (Cui *et al*., 2016).

Cytochrome P450s

The cytochrome P450 superfamily is involved not only in the metabolic processes of hormones, lipids and secondary metabolites, but also in the hydroxylation or detoxification of ACCase, ALS and Photosystem II (PS II) inhibitors. It also plays an important role in detoxifying herbicides (Yu and Poweles, 2014). However, to date only one cytochrome P450 gene has been identified in rice that can enhance plant resistance to bentazone, a selective herbicide that can inhibit photosynthesis. This gene destruction renders plants

susceptible to bentazone. Discover more about this family of supergenes to enhance the detoxification capacity of different herbicides, beneficial for molecular manipulation and breeding of herbicide tolerant crops.

Conventional approaches to develop herbicide tolerant crops

There are many approaches to developing herbicide-tolerant crops, but the traditional approach has been widely adopted because of its ease of regulation and widespread acceptance by consumers. Apart from that, there are also transgenic approaches, but these are highly regulated and less accepted by consumers. Screening for natural variability of genetic resource lines of different origin.

- Screening for natural variability of genetic resource lines of different origin.
- Use the available genes present in the gene pool or the genes present in wild relatives.
- Random mutagenesis to create variations of herbicide resistance.

Germplasm screening

The screening is done by spraying herbicides. It very well may be finished by developing lines and use of different portions of herbicides and assessment is finished by taking different parameters, for example, normal plant strand, yield contrast among control and sprayed plot, days to blooming, days to maturity, Normalized Vegetation Difference score (NDVI), leaf damage score (0-5 scale) and floral development. The best line is additionally screened at multi areas in long term.

Mutant screening

Mutation is being an important source of creating variability in the crops where no availability of enough variation for herbicide tolerance. Mutations may be created by either physical or chemical mutagens and then screening of these mutants can be done by spraying with herbicides. Finally, these mutants can be directly released as varieties or utilized in the breeding programmes.

Non-conventional approaches for herbicide tolerance

Herbicide tolerant crops also generated by novel breeding approaches like site directed muatagenesis, somaclonal variation, gene editing and transgenics. These approaches are characterized under following.

Site directed mutagenesis

The gene that the herbicide targets can be mutated in a way that does not affect other functions of the gene. Site-directed mutagenesis is oligonucleotide

mutagenesis, and modified nucleases can be used to create herbicide tolerant cultivars.

Agriculture Victoria Services Pty Ltd used sodium azide (AZ) and methylnitrosourea (MNU) to mutate rice grains and obtained a quizalofomethyl resistance mutant. This mutant has a G to A mutation in the carboxytransferase coding region of ACCase, resulting in a Gly2096Ser mutation and resistance to ACCase inhibitor herbicides (hinga *et al*., 2013). The first approved Provisia PVL01 rice is BASF 1–5. BASF 1-5 is an unpublished rice line that is resistant to ACCase inhibitor herbicides and contains the Ile1781Leu mutation in the ACCase protein.

Gene editing

Homologous recombination and substitution of herbicide target space of target chemical with transformed variant not appropriate for herbicide restricting can be a decent methodology for herbicide resistance.

Transgenic

Herbicide resistance is the most well-known attribute in the business transgenic crops as 47% (80.7 Mha) of all out region under transgenic crop on the planet is under transgenic herbicide resistant (189.8 Mha) (ISAAA site). Transgenesis for herbicide tolerance involves

identification of donor gene and its isolation, cloning, stable integration and finally expression of that trait in the target organism. In the majority of the part, genes coding for herbicide resistance are isolated from herbicide debasing soil microorganisms. Agrobacterium mediated and particle bombardment methods are generally utilized in hereditary change of yield plants in light of their high productivity. Herbicide resistance might be presented by one or blend of four systems referenced underneath.

- Introduction of genes coding for enzymes that can degrade the herbicides.
- Modification of herbicide target enzyme in such a way that it can’t bind to herbicide.
- Engineering for active herbicide efflux from plant body.
- Introduction genes coding for insensitive form of a target enzyme for herbicides or over expressing of enzymes in order to compensate the plant normal metabolic activities even through some enzymes are inhibited.

Application of herbicide resistance genes in rice

Over expression of foreign genes in rice

Plant-derived EPSPSs are generally sensitive to glyphosate, but EPSPSs isolated from glyphosate-resistant bacteria have reduced binding affinity for glyphosate and are therefore better tolerated. Most glyphosate-resistant rice lines have been created through transformation techniques by introducing the EPSPS gene from resistant bacteria into plants. The codon-optimized CP4 EPSPS gene from Agrobacterium tumefaciens was transfected into rice cultivar IR64 to produce transgenic plants that can tolerate 10 times the recommended glyphosate dose (Chhapekar *et al*., 2015).

There have also been several transgenic events that have combined EPSPS resistance genes with untargeted glyphosate resistance genes to improve glyphosate resistance in rice. Fartyal *et al*. (2018) transformed mutant rice EPSPS and igrA genes into Indica Swarna to produce transgenic rice with high glyphosate tolerance and low content of herbicide residues. Cytochrome P450 is present in all most all organisms and it's over expression in rice can enhance the resistance to herbicides, generally with different modes of actions. Transferring the common human cytochrome P450 gene CYP1A1, CYP2B6, and CYP2C19 into Nipponbare japonica rice, the resulting transgenic plants showed resistance to various herbicides, including the root elongation inhibitor (pyribeticarb), which very long chain fatty acid inhibitors (acetochlor, metolachlor and thenylchlor), photosynthetic inhibitors (chlortoluron) and carotenoid biosynthesis inhibitors (norflurazone) (Kawahigashi *et al*., 2004).

Rice gene editing

In recent periods, gene editing technology, particularly CRISPR/Cas9 (Clustered regularly interspaced short palindromic repeats/CRISPR associated 9) mediated genome editing has been widely used in the genetic modification of microorganisms, animals and plants (Table. 1). CRISPR/Cas9 technology coaxes the Cas9 protein into target genomic DNA under the direction of sgRNA and induces a DNA double-strand break (DSB) at the target site, creating non-homologous end junction (NHEJ) pathways and homologous recombination (HR) in cells, allowing precise genome modifications such as targeted inactivation, substitution and insertion of a DNA fragment.

Table 1: Herbicide-resistant rice obtained through gene editing

Target gene	Editor	Mutated site	Herbicide	Generation of rice	Reference
EPSPS	CRISPR/Cas9	Thr102Ile + Pro106Ser (TIPS)	Glyphosate	T0, T1	Li *et al*. (2016)
ALS	CRISPR/Cas9 Target-AID BEMGE	Trp548Leu + Ser627Ile Ala96Val Pro171Phe	Bispyribac sodium Imazamox Bispyribac sodium	T0 rice calli T0, T1	Sun *et al*. (2016) Shimatani *et al*. (2018) Zhang *et al*. (2020)
TubA2	rBE14	Met268Thr	Pendimethalin, trifluralin	T1	Liu *et al*. (2020)
ACCase	STEMEs eABE, eBE3	Pro1927Phe, Trp2125Cys Ile1879Val, Trp2125Ser, Cys2186Arg	Haloxyfop Haloxyfop-R-methyl	T0 T0, T1	Li *et al*. (2020) Liu *et al*. (2020)

Application of herbicide-resistant rice in commercial production

Commercialized herbicide-tolerant rice varieties include Liberty Link, Provisia, Clearfield rice, and Jietian varieties. Liberty Link rice confer resistance to glufosinate by introducing the pat gene from Streptomyces hygroscopicus. Rice Provisia resistant to ACCase inhibitors were produced by BASF in Germany using a non-transformation approach. PVL01 is Provisia's first approved rice. Clearfield rice with a Ser627Asn mutation in the endogenous ALS gene is currently the best-known herbicide-tolerant rice. Clearfield Rice confers resistance to IMI herbicides, a class of highly effective herbicides that are effective against a wide range of weeds. It was first released in the United States in 2002.

Table 2: List of Non transgenic Herbicide-Resistant Crops (Green and castle, 2010)

Selection method	Herbicide type	Crop
Whole plant	Triazine	Canola
Seed mutagenesis	Terbutryne	Wheat
	Sulfonylurea	Soyabean
	Imidazolinone	Wheat Rice
Tissue culture	Sulfonyl urea	Canola
	Atrazine	Soyabean
	Imidazolinone	Corn
	Sethoxydim	Corn

Cell selection	Imidazolinone	Sugarbeet
Pollen mutagenesis	Imidazolinone	Corn
Microspore selection	Imidazolinone	Canola
Transfer from weedy relative	ALS inhibitor	Sunflower Sorghum
	Accase inhibitor	Sorghum

Future research and development of herbicide-resistant rice

Discover new genes and develop new herbicide-resistant rice

Currently, glyphosate and glufosinate-resistant rice are mainly produced through transgenic technology, and the safety of transgenic rice is still controversial around the world, limiting the commercial application of herbicide-tolerant transgenic rice. CRISPR/Cas9 and a variety of other gene editing systems developed on this technology provide effective ways to modify the endogenous genes of rice, leading to the development of new herbicide-resistant rice. Genetically engineered transgenic plants can be self-fertilized or crossed with non-transgenic plants to isolate the CRISPR/Cas9 transgene from the target mutation and yield progeny without the transgene. These offspring are, in nature, the same as natural mutants and mutants produced by artificial mutagenesis.

Reducing the risks associated with herbicide application

The safety and environmental impact of herbicides are a major public concern. The ideal herbicide should be safe and non-toxic to humans and animals before it can be used on commercial platforms. Herbicides enter the soil after application and damage the soil ecosystem. After adding the herbicide to the soil, it was shown that the biomass of soil microorganisms was significantly reduced, the enzyme activity in the soil was inhibited, and the activity and density of the microbial community and microbial diversity were also reduced. Due to their sensitivity, they also cause problems with subsequent crops. Traditional methods such as irrigation, cultivation, and application of biochar and humic acid reduce herbicide residues in the soil. Currently, biodegradation of herbicides by microorganisms is effective. Herbicide degradation depends primarily on the type of soil and its physical and chemical properties, as well as the diversity of microorganisms. Another important issue is food safety associated with herbicide residues in the facility, which is a major concern of the general public. This has sparked intense debate about the use of herbicides, especially after the International Agency for Research on Cancer (IARC) concluded in March 2015 that glyphosate was likely to be carcinogenic (Tarazona *et al*., 2017). The best way to deal with

this problem is to evolve herbicide-tolerant crops into safer herbicides. Alternatively, the development of herbicide-tolerant plants with increased herbicide-degrading activity may provide a solution. In experiments on detection and safety assessment of residues after spraying high doses of IMI herbicides, brown rice, rice husks, and straw herbicide residues at harvest for herbicide-tolerant rice were below acceptable doses. A molecular approach to increasing the ability of plants to rapidly degrade herbicides, as they can not only improve the resistance of plants to herbicides, but also reduce herbicide residues to increase food safety.

Disadvantages of herbicide tolerant crops

a) Harmful to mammals due to long-term use of herbicides.
b) Risk of environmental damage (soil microbes and sequelae to green or climate of agriculture).
c) Development of weeds (superweed) that are safe for herbicides.
d) Individual determination of burden and weed blockage.
e) Changes in the population of weed species (small weeds can grow into large weeds).
f) Quality flow (shift of transgenic attributes to related wild weed species by fertilization).

Benefits of transgenic herbicide tolerant crops

a) Facilitate low or no tillage.
b) More extensive range of weeds controlled.
c) Decreased crop injury.
d) Diminished herbicide persist.
e) Utilization of herbicides that are all the more harmless to the ecosystem.
f) New method of activity for opposition the board.
g) Crop the executives adaptability and straightforwardness.

Conclusion

Herbicide tolerant crops are now required to popularize the mechanized agriculture and also to mitigate the shortage of labour and to increase the efficiency of natural resources like water under direct seeded conditions where the weeds are the major problem. Based on the wide amount of genetic variability available in various crops and with advancement of various molecular biology tools and gene editing tools, we can now be sure to develop herbicide tolerant cultivars along with yield related desirable traits.

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Chapter - 9
IoT Based Photoelectric Animal Motion Detection

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Chapter - 9

IoT Based Photoelectric Animal Motion Detection

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Abstract

In this paper, we projects about IoT Based photoelectric Squirrel Motion Detection system using Arduino &GSM module SIM800A. In our country every year, Squirrels cause a big economic harm. Hidden and normal herd of Squirrel's attacks plants and field gradually but it causes huge harm in agriculture area and snakes like dangerous animal harms the farmers and local community too. Ancient strategies are being followed by farmers aren't much effective and it's not being feasible to hire guards to keep an eye fixed on the crops and forestall the animals. So here, in this paper we have used the design of an IoT based photoelectric Squirrel motion detection that comprises of a motion-sensor, a GSM module, an Arduino Uno board and a Buzzer. This detects the Squirrel by using a motion sensor. Once presence of Squirrel confirmed the Arduino Uno board starts the Buzzer which produces ultrasonic sound waves by which the animal or insect goes away from that area and a memorandum will be sent by using GSM module and then farmer get ready for protecting. This approach will drastically reduce the use of pesticides, Squirrelicides in the agriculture and reduces the exposure of crops from these harmful chemicals and eventually we will be producing healthy and fresh goods. The Indian economy accepts security in terms like protection from attacks of Squirrels in fields. Hence, this work focuses on raising a smart agriculture using IoT technologies.

Keywords: Arduino UNO, PIR sensor, GSM module SIM800A, buzzer

I. Introduction

Agriculture sector plays key role for India's gross domestic product (GDP). Risk Factors such as economic conditions, bad weather conditions, human resources, animals, labor cost are the barriers for growth of agriculture sector. But, Due to population explosion it is necessary to increase the crop yield. To improve the yield, soil quality must be better. IoT based photoelectric Squirrel motion detection in backyard farming helps people in

detecting Squirrels using PIR (Passive Infrared) motion sensor and repelling them by producing Ultrasonic sound waves.

Ultrasonic wave defines a frequency band with a frequency range more than 20 kHz. Humans are not capable to hear this ultrasonic audio. Because the eardrum of human will not vibrate rapid but insects can listen this ultrasonic sound effectively. Ultrasonic sound creates repellent and noisy climate which repels animal and insects. It also alerts the farmer through message, thus helps him in protecting the plants and increases overall yield.

II. Problem statement

In today's world, the process of controlling Squirrels and other animals from destroying the crops has been a great challenge to the farmers. Due to population explosion, it is necessary to increase the crop yield and decrease the loss of crops. Many systems have used different sensors to detect the Squirrels and have tried many ways to eradicate them but were not able to achieve it completely. In this system we have an IoT module that uses a PIR sensor which detects the Squirrels entering the farm and repels them by producing Ultrasonic sound waves and alerts the farmer by sending a message to his phone.

III. Scope of the project

- The Animal is detected using PIR sensor.
- Buzzer produces ultrasonic waves to make them uncomfortable and scare them away.
- An alert is sent to the farmer via text message to notify the intrusion.

IV. Literature survey

Sensor based Crop Protection System with IOT monitored Automatic Irrigation [1]. Authors: Damini Kalra, Praveen Kumar, K Singh and Apurva Soni, International Conference on Advances in Computing, Communication Control and Networking (ICACCCN), 2020. In this system, the automatic irrigation is done with the help of 2 soil moisture sensors which calculates the moisture percentage in the soil in real time. This information is then transmitted to the microcontroller in voltage form where the code starts executing and finds average of the moisture level detected by the 2 sensors. The temperature, humidity and the soil moisture data are sent to the microcontroller from where it is transferred to NodeMCU via serial communication. NodeMCU is a Wi-Fi module which allows the user to monitor the physical parameters through mobile phones. The system also protects the crops with a two-mode protection system for day and night along

with automated irrigation with IoT monitoring. The movement detection system and the sound detection system ensure the crop protection with the help of high frequency sound emitted on the algorithm basis. In the night, along with the movement and sound detection, a lower frequency sound emitter for small insects is activated to protect the crops from pests and insects which come out in the night.

Smart Crop Protection System from Animals [2]. Authors: M. Jaya Prabha, R. Ramprabha, V. Vasu Brindha and C. Asha Beaula, International Journal of Engineering and Advanced Technology (IJEAT), 2020.In this system, they designed an animal detection system to detect the presence of animals and give alert to the farmer as well scare away the animal without any harm. They monitor crops by placing appropriate sensors in the field. They used ultrasonic sensor, IR and GSM. The sensor is used to detect the animals. Once the animal gets detected, this signal is then to the microcontroller for further processing and the system gets activated immediately on the APR board, and then the sound is played to scare away the animal, and to alert the farmer, the system automatically gives call to the farmer. The ultrasonic sensor is placed on the motor so that it rotates 360 degrees, to sense the presence of animals and birds on all directions. Microcontroller is the main component in this system, as it reads all the inputs from different sensors and components and then based on those inputs, gives signal to other components to get desired result. The GSM module as a mobile device to make call to the farmer. It alerts the farmer that some animals or birds try to enter into the farm. Thus, this system ensures the protection of the field by using various sensors and components.

IOT Based Smart Squirrel Detection and Fire Alert System in Farmland [3]. Authors: T. Sowmika, L. Rohith Paul and G. Malathi of Computer Science and Engineering, Vellore Institute of Technology. International Research Journal of Multidisciplinary Technovation (IRJMT), 2020.In this paper, they designed a smart and safe agriculture system that would notify the farmer about the lack of moisture in the soil, animals and others trespassing in their field at odd times using IOT. They used flame sensor to detect fires in the farm and soil moisture sensor to find the moisture content in the soil and then send the data to the farmer. They used PIR and ultrasonic sensor to detect animals and other living beings which are trespassing in the field. All these sensors are controlled with the help of raspberry pi module. They used Wi-Fi module is to send the data received from the sensor to a cloud service platform which analyze the data and perform the required operations like turning on the motor and buzzer. This approach that can be used to solve this

problem is using IOT based sensor networks to assist the current traditional methods that are used by the farmers in order to improve their efficiency. The Indian economy accepts security in terms like protection from attacks of Squirrels in fields. Hence, this work focuses on raising a smart agriculture using automation and IOT technologies.

Low-Cost Wireless Sensor Network for Squirrels Detection [4]. Authors: Carlos Cambra, Sandra Sendra, Laura Garcia and Jaime Lloret, International Conference on Advanced Computation and Telecommunication (ICACAT), 2017.In this paper, they designed a system with less energy consumption and used low-cost microcontrollers They deployed multiple devices which works in real time and are used to monitor the Squirrel. They collect the data of Squirrel motion detection and the trapping estimations for further analysis. This data is collected periodically, like weekly or monthly and sent to multimedia platforms like mobile or computers. This paper also uses PIR sensor to detect the Squirrels. The main aim of this system is to use the micro-RF transceivers which costs less than 5$ and also to reduce power consumption. This system is a WSN that combines many commercial hardware and software components that integrate several smart implementation algorithms for network routing. This paper also shows how IoT, with network algorithm routing, can be used in large and smart Squirrel-detection network systems which are expensive in the current market and which should be scalable and easily configurable. On a mesh network, it integrates intelligent frameworks, low energy consumption and the implementation of sensors using the new communication chips based on 2.4 GHz.

Smart Ultrasonic Insects & Pest Repeller for Farms & Inventories Purpose [5]. Authors: Prafful Silakari, Prerna Silakari, Litesh Bopche and Aparna Gupta, International Conference on Advanced Computation and Telecommunication (ICACAT), 2017. This paper proposes an agriculture monitoring system, main goal is to protect the farm and notify it to the farmer. They use ultrasonic sensor and motion sensor to detect the sound and motion of trespassing animals which ensures the presence of the animal in that range. They used Arduino Uno board to control all these sensors and make it work as per the needs. After confirming the presence of the animal, it sends signal to the Arduino board, which sends an alert to the farmer. This alert is sent via GSM Module, which acts as a mobile device. At the same time, it triggers a repeller which emits ultrasonic. This causes irritations to the animals, and they are forced to leave the farm, hence protecting the crops from the animals. As a result, this system serves as a cost-effective and efficient system for

monitoring and protecting agricultural farms without any human interventions required.

Animal Detection System in Farm Areas [6]. Authors: Vikhram B, Revathi B, Shanmugapriya R, Sowmiya S and Pragadeeswaran G, International Journal of Advanced Research in Computer and Communication Engineering, 2017. In this paper, they proposed an animal detection system, which detects the presence of animal using sensors and notify the farmer about the intrusion. To detect the presence of the animal in the farm, they used PIR and Ultrasonic sensors, which detects the motions and as well as sound, hence ensures the presence of the animal. Once the presence of animal is confirmed, the signal is sent to the APR board, which plays sound to divert the animal from the farm. They used Light dependent resistors (LDRs) to find whether it is day or night, if night then the flash light is switched on for visibility at night. They have 2 types of power source, Solar panel and regulated power supply for this system. An LCD display is also used in this system which displays the presence of the animal and as well as the LDR readings. To alert the farmer, a SMS is sent the farmer to notify about the intruder. Overall, this system is designed to protect the farm the farm from intruders without causing any harm to the ecosystem.

Design of Birds Detector and Repellent Using Frequency Based Arduino Uno with Android System [7]. Authors: Yahot Siahaan, Bheta Agus Wardijono and Yulisdin Mukhlis, International Conferences on Information Technology, Information Systems and Electrical Engineering (ICITISEE), 2017. In this paper, they created a bird and pest repellent system using ultrasonic sound. It consists of PIR sensor, which acts as a detector and detects the presence of bird. They use LC oscillator type Colpitts and Piezo Ultrasonic sensor used as repeller to cause irritations to the bird and scare them away. The working range of the detection is 0cm-500 cm and they set the ultrasonic frequency to 60 kHz. The frequency used by the author is in range 20 kHz-29 kHz. This frequency is chosen because the ultrasonic frequency that can be heard by the bird senses reaches only 29 kHz. This desired frequency is derived by changing the capacitor capacitance value. This whole prototype is controlled by an Arduino Uno board, which receives and sends signals to all the sensors and other components. This prototype is integrated with an android app. So, all the events are recorded in the android app which can be used to monitor by the farmer and get notifications.

Solar Powered Smart Ultrasonic Insects Repellent with DTMF and Manual Control for Agriculture [8]. Authors: Humayun Rashid, Iftekhar Uddin Ahmed, S M Taslim Reza and M. A. Islam, IEEE International Conference

on Imaging, Vision & Pattern Recognition (icIVPR), 2017. This system is designed for agricultural purpose, but can be used for other domestic purpose also. Two modes are provided in this system namely, auto mode and manual mode, which can be switched as per their requirements. Using ultrasonic sound-based system is better than other conventional chemicals pesticides, which cause harm to the environment and to the economy. The frequency can be varied as per requirements in this system, so that we can manipulate the frequency to repel many kinds of insects. This system can be controlled from any distance using DTMF (Dual Tone Multi Frequency) technology. DTMF is a technology that can be used to control devices from any distance by using GSM mobiles. It also has night mode with manual control using Light Dependent Resistor (LDR). Power supply is provided with the help of solar panel which is cost effective and good for environment. All these components are controlled using an Arduino Uno board, where it has been coded to perform certain operations on the components.

Solar Energy Driven Arduino based Smart Mosquito Repeller System [9]. Authors: Simarjit Singh Saini, Divya Bansal, Gurnoor Singh Brar and Ekambir Sidhu, IEEE WiSPNET 2016 conference, 2016. Ultrasonic waves whose frequencies are higher than 20khz are not audible to humans. But these waves affect other insects since they are sensitive to these waves. Mosquitos contain special hair called sensible which is present on the antennae which gets affected due to these waves. This affects their nervous system and eventually they are forced to leave that area. 38-44 kHz is the frequency range that can be used to divert these mosquitoes and flies. The proposed ultrasonic mosquito repeller system operates by harvesting the solar energy from sun during daytime and storing it in rechargeable lead acid battery and utilizing the harvested energy to turn on and operate the ultrasonic mosquito repeller system during evening and night time. The relay act as switch which turns repeller on and off based on Arduino instructions. When repeller is turned on by relay and Arduino, it generates ultrasonic sound waves which can be efficiently used to repel the mosquitos from specified area. The range of this proposed system is around an area of 125 square meters.

Ultrasonic Sensor Animal Safety System [10]. Authors: Vijayaraghavan Sundararaman, Vijayalakshmi TG and Swathi Venkatadri, IEEE International Conference on Recent Advances and Innovations in Engineering, 2014.This module is designed to protect and prevent animals (especially dogs) from the road accidents. Many people get injured when their vehicle comes in contact with domestic or wild animals on the road. Research shows that these animals have been responsible for most of the read-end collisions. The mail goal of

this system is to design an ultrasonic sound wave generator that can be used to divert the animals from the roads. The ultrasonic sound cannot be heard by humans but dogs and other animals have the ability to hear these sound. So, we design an ultrasonic wave generator to generate waves that can divert the animals. This system is powered by solar panels, to enhance the efficiency of the system. The ultrasound generator is basically a transmitter that transmits the ultrasound in the surrounding using air as medium and also this ultrasonic generator acts as the repeller for dogs. This will generate a frequency of 40khz which is irritating frequency for the dogs that humans cannot hear. This high-pitched sound when heard by the animals, they gets irritated and leaves that area, eventually preventing the accidents. This system can be used in forest areas, where the movement of animals in roads are more frequent and thus reducing the accidents.

V. Proposed system

The sensors used in this system is PIR (Passive Infrared) sensor. This sensor is attached with Arduino uno and GSM module SIM800A. In this System, we can detect the Squirrels and other animals whenever they try to enter the field. We can stop the Squirrels and other animals from destroying the crops by repelling them. Meaningful research documented that ultrasonic-wave achieve Squirrel repeller impact and also decrease in the combine as well as an imitation of numerous pests. We can alert the farmer in real time via text message whenever the Squirrels and other animals enter the farm. Previously, the farmer had to monitor his field frequently for pests and animals which can destroy his crop which is a loss of time and can incur lot of financial loss to the farmer, but with this project the farmer can monitor his crop and in case any pest enters his crop, he will be alerted instantly so that he can take proper action saving him lot of time and the money that he invested in the crop. This research work not only supports the farmers but also provide benefits in the productivity.

5.1 Circuit diagram

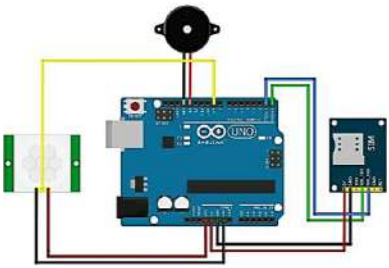

Fig 5.1: Circuit diagram

VI. Circuit diagram description

This Squirrel Motion Detection system consists of an Arduino UNO Board, a PIR (Passive Infrared) Sensor, a GSM (Global System for Mobiles) module and a Buzzer.

6.1 Arduino board

The Arduino Uno is used to control all sensors and components of our system. It is the main component of our system that controls the working of all the other components. We have written the code using the Arduino IDE and embedded the code into this board to control these components as desired. PIR sensor, GSM Module, Buzzer are all connected to this board. Whenever the PIR sends a high voltage to the Arduino board, the buzzer is switched on to produce ultrasonic wave of 25kHz frequency. This frequency is already set in the code. At the same time, it also sends the pre-written alert message to the GSM module, and then that message is sent to the desired mobile device. The message and receiver's mobile number are set in the code itself.

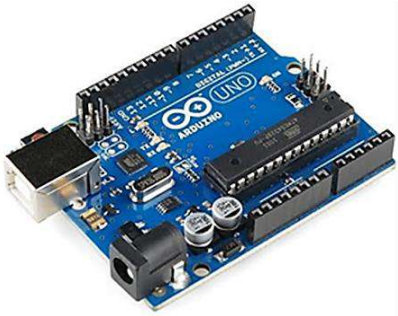

Fig 6.1: Arduino UNO

6.2 PIR Sensor

PIR is used to detect any warm, infrared radiating object in its range. It consists of a pyroelectric sensor it its center, which generates high voltage with the help of the infrared radiation. The sensor is covered by Fresnel lens, which concentrates the radiations to the sensor for better sensing purpose. It also consists of 2 potentiometers, 1 which is used to control the sensitivity of the sensor, range can go up to 6 meters, and another potentiometer is used to control the output delay time, which ranges from 0.3 seconds to 5 minutes. It also has 2 trigger modes, one is repeatable trigger, which keeps the output voltage high until the radiation is present in the sensors range. Second mode is non-repeatable trigger, which will keep the output voltage high until the

delay time is over. We are using repeatable mode here for our prototype, and setting the delay time to minimum.

Fig 6.2: PIR Sensor

6.3 GSM module

We use GSM module to establish communication between our prototype and the farmer's mobile device. We use 9V battery as a power supply to this circuit. A SIM is inserted into the circuit, which acts as a mobile device. It is connected to the Arduino board via Transmitter and receiver pins and controlled by the Arduino board, where we have written code to send SMS to alter the farmer whenever the PIR sensor detects a Squirrel or any animal in its limited range.

Fig 6.3: GSM module

6.4 Buzzer

Using PIR Sensor, the Squirrels are detected. Whenever, any impediment comes ahead of the PIR sensor the buzzer produces ultrasonic sound waves of 25kHz frequency which causes an irritation to the Squirrels and forces them to stop moving towards the crops and protects the crops.

Fig 6.4: Buzzer

VII. Experimental results

Fig 7.1 shows the prototype of IoT Based Photoelectric Squirrel motion detection. The red LED glows whenever any infrared radiating object (Squirrel and other animals) is detected in its area.

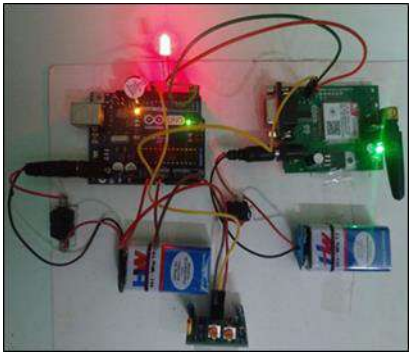

Fig 7.1: Prototype of IoT Based Photoelectric Squirrel motion detection

As shown in below fig 7.2shows the measurement of frequency produced by the buzzer when the animal is detected by the PIR sensor.

Fig 7.2: Ultrasonic sound frequency measurement

VIII. Conclusion and Future work

Proposed system detects Squirrels and emits ultrasonic sound waves that repel them. So that wild animals will not enter into the farm. It will run away. GSM module sends message to the farmer to alert him. Here we use a PIR sensor as a detector with a movement distance that can be captured from a Squirrel is 6m, according to the characteristics of the sensor. When Squirrels are detected then the Squirrels will automatically be given with ultrasonic waves. From this it is concluded that the design system is very useful and affordable to the farmer. IoT Based Photoelectric Squirrel Motion Detection serves as a reliable and efficient system for monitoring agricultural losses. The corrective action can be taken. The design system will not be dangerous to animal and human being, and it protects farm. Wireless monitoring of field not only allows farmer to reduce the man power, but it also allows user to see efficient and accurate changes in it and by the data government and farmers welfare, MNC's make good policies. It is cheaper in cost and consumes less power. The GDP per capita in agriculture sector can be increased. This project can be extended for cattle monitoring also.

In the future, there will be very large scope; this project can be made based on wireless networks. Wireless sensor network and sensors of different types can be used to collect the information of crop conditions and environmental changes and this information can be transmitted through network to the farmer that initiates corrective actions. Farmers are connected and aware of the conditions of the agricultural field at anytime and anywhere in the world.

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Chapter - 10
Upcycling Wastewater Treatment Plant Sludge into Eco-Friendly Cement Mortar

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Chapter - 10

Upcycling Wastewater Treatment Plant Sludge into Eco-Friendly Cement Mortar

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Abstract

Aiming to create alternatives for the disposal of sludge generated in wastewater treatment plants (WWTP) considering the circular economy principles and contributing to the reduction of environmental impacts generated by civil construction, the objective of this work was to evaluate the technical feasibility of the partial replacement of cement in the production of mortars by the sludge produced at the Bragança WWTP. The sludge was characterised, and different methods were used to prepare the sludge for the mortar. The sludge was incorporated by replacing part of the concrete mass of the mortar mixture. The specimens were tested for compressive strength. The specimen with 7% of sludge ash obtained the best result, the specimens with sludge from the drying-only treatments showed a result similar among themselves. The incorporation of the sludge resulted in mortars within the specification of the standard EN 998-1: 2018 and consequently have technical feasibility.

Keywords: Circular economy, economic valorisation, mechanical strength, sludge ash, sludge sun dry

Introduction

The circular economy is a sustainable, regenerative, and restorative production strategy, as it implements a system in which all types of materials are extracted and designed to circulate efficiently and, without loss of quality, are put back into production1. In this way, goods that are at the end of their useful life are transformed into resources for other production processes, closing cycles in industrial systems and minimising waste [1].

To avoid waste and loss of economic-environmental value the circular economy strategy suppresses inefficiencies in the production process by efficiently managing natural resources, minimising, or eradicating waste creation and maximising the life and value of products [1].

Over the years, water consumption presents a growing trend and aligned to this, the amount of sludge generated in WWTPs increases [2]. In 2020 in Portugal, more than 333 thousand tonnes of sludge were processed by wastewater treatment plants [3]. Due to a load of residual organic pollutants, toxic metals and pathogenic microorganisms present in sewage sludge, adequate treatment and disposal processes are essential for the protection of public health and the preservation of the environment [4]. Although classified as waste, sewage sludge can be used as a source of energy or resources, which represents a possibility of waste management within the concept of circular economy [4]. There are techniques to recover nutrients such as phosphorus and nitrogen, heavy metals, sludge-based absorbents, proteins, and enzymes from sewage sludge [4]. One way to manage the volume of sludge produced sustainably is to combine the mineralogical composition of the sludge, which is essentially hydroxides and oxides of silica, aluminium and ferric with the production/application in construction materials [5]. It is possible to apply sludge in construction materials such as in the production of lightweight aggregates, bricks, interlocking tiles, coal, and slag. Sludge can be used as an energy source with the production of biogas or in the use as biofuel [4].

It is necessary to eliminate volatile compounds and degrade the organic matter in the sludge before their incorporation into construction materials. This is because organic matter can degrade or decompose causing changes in the manufactured product, thus reducing its durability [6].

Thermal processes have the advantage of reducing volume and weight, destroying toxic organic compounds, including pathogens, minimizing odours, and recovering energy through steam turbines [7]. Incineration involves the complete oxidation of the volatile matter and the production of an inert residue-ash [7-8]. In the European Union, about 22% of the sewage sludge is incinerated [9]. The resulting ash has a high content of heavy metals, so the correct final disposal can become a problem. The incorporation of ash in construction materials is an alternative that results in stable and safe products [7-8].

Nowadays cement is the most widely used building material and concrete is the most consumed material worldwide [10]. There are impacts generated in practically all the productive phases of cement, such as extraction, production, and even final disposal [11-12]. CO_2 emissions from the cement industry represent more than 5% of world emissions and are expected to reach 30% in 2050 [11].

To reduce the environmental impact of mortar and concrete due to the cement manufacturing process, the incorporation of residues in these civil

construction products should be encouraged [12]. The incorporation of waste in civil construction describes an alternative to reduce the volume of waste deposited in landfills and reduce the volume of mined materials, minimizing the environmental impact that the construction industry has on the environment [11]. There are potential end uses of by-products such as building fillings, concrete aggregates, and pavements. In the environmental scenario, the replacement or complementation of a binder in a concrete product is one of the most interesting applications, such as the replacement of cement in concrete [11].

Aligning sustainable construction practices with waste management makes the implementation of WWTP sludge in construction products an alternative to minimize the impacts generated by cement industry and at the same time provides a safe and stable sludge destination [11-13]. Thus, this study aims to produce and evaluate, in relation to technical feasibility and economic valorisation, ecological mortar produced from the replacement of cement by WWTP sludge. The sludge was characterized and subjected to different thermal treatments before being incorporated into the mortar. The technical feasibility of the treatments was discussed according to the mechanical resistance that the produced specimens obtained. The economic feasibility of the methods was evaluated according to the energy expenditure of the sludge treatment processes in relation to the energy expenditure of cement production.

Materials and methods

Sludge samples was obtained from a local wastewater treatment plant in Bragança, Portugal, of the company Águas de Trás-os-Montes e Alto Douro-Águas do Norte Group.

Sludge characterisation

The incorporation of sludge in mortar can affect the durability of the manufactured product due to the presence of organic substances, so the sludge characterization under analysis is essential [13]. Sludge characterisation included pH, moisture, total solids (TS), and organic matter (OM).

The pH determination was based on Embrapa's (1997) soil pH analysis methodology [14].

The determination of moisture and TS was carried out simultaneously based on Standard Methods for the Examination of Water and Wastewater (2005) [15].

To determine the OM content a mass of approximately 250 mg of dry and ground sludge was mixed with 10 mL of 1N potassium dichromate solution

and 20 mL of concentrated sulfuric acid in light agitation and then left to rest for 30 minutes [16]. After this period, 200 mL of distilled water, 10 mL of concentrated orthophosphoric acid and 1% ferroin indicator were generated, which was then titrated with a 0.5N of ammoniacal ferrous sulphate solution until obtaining a green colour16. The blank was performed with the same procedure described above, but without the addition of the sludge sample16. The calculation of the OM is given in equation (1):

$$OM = 1.725 \times (10 - (V_2 \times 10 \times V_1^{-1})) \times 0.4/m$$

(Equation 1)

Where:

OM represents the organic matter content in %, V_1 the volume of ammoniacal ferrous sulphate spent on white titration in mL, V_2 the volume of ferrous ammonia sulphate spent on the titration of the sludge sample in mL and m the mass of sludge sample analyzed (g).

Sludge preparation

To make the specimens with the replacement of cement by sludge, the sludge was processed. Different methodologies have been proposed to study the influence that sludge processing has on the mechanical strength that the specimen acquires.

Method 1: Dry Sludge

The making of specimens with only dry sludge, serves as a standard for the other analyses since the sludge had only water removal, without other physical or chemical changes.

The temperature and drying time were determined based on the work of Nakic [17], Gonçalves *et al*. [6], and Silva [18]. The sludge was dried at 105 °C for 24 hours.

Methods 2 and 3: Dry Sludge in the Sun

A sludge sample was left in the sun to dry naturally, as in Awere, Bonoli and Obeng's [19] work, however for a period of 7 and 15 days, while the author left it for a month. To increase drying efficiency, a thin layer of sludge was used in an aluminum container, this system was exposed to the sun every day of the experiment period and was covered at night to avoid dew or rain. The residual moisture was determined after the drying period in the sun (105 °C for 24 hours).

Method 4: Incineration

The dried sludge (105 °C for 24 hours) was burned for 0.5 hour at 300 °C and for 3 hours at 900 °C in a muffle furnace. The residence times and temperatures were defined based on the work of Hagemann *et al*. [20], Melo *et al*. [21], Nakic [17], and Gonçalves *et al*. [6]. To burn the sludge in these temperatures and combustion times ensure complete decomposition of the sludge organic matter [17]. Furthermore, mineralogical alterations enable the rearrangement of the matter which increases the pozzolanic activity of the material [13].

Mortar specimens

The specimens were produced with tap water, sand with a grain size of 0.4 mm and limestone Portland cement. All specimens produced have the same concentration of sand and water, 54% and 14% respectively. The cement was replaced at 0, 3, 5, 7 and 10% by the ground sludge treated in each of the methodologies cited above.

The preparation, production and storage of the specimens followed the EN 1015-11:2019 [22].

Mechanical tests

The mortars were tested on 7-day age of curing and on 28-day age of curing. Two mechanical tests were carried out onto the specimens, flexural strength and compressive strength tests. The tests were carried out in accordance with the EN 1015-11:2019 [22].

In the flexion test, a force is applied in the horizontal centre of the specimen until its rupture. In the compression test a force is applied 4 cm from the end of the specimens until the peak of the applied force is formed.

Statistical analysis of the compression data was performed. The data were submitted to one-way analysis of variance (simple ANOVA) by Tukey's honestly significant difference (HSD) procedure to compare the means with 95% confidence level. Statistical analyses were performed with Statgraphics Centurion software.

According to the EN 998-1 standard, the mortar is classified by the compression resistance that the specimen supports on the 28-day age of curing [23]. The standard classifies mortar in the following categories: CS I, CS II, CS III and CS IV. The compressive strength ranges are: from 0.4 to 2.5 MPa, from 1.5 to 5.0 MPa, from 3.5 to 7.5 MPa and more than 6 MPa, respectively [23].

Economic viability

The economic viability was evaluated according to the energy costs of each methodology in the preparation of the sludge, and how much the replacement of cement by sludge represents energy savings/expenditure in the energy balance of the mortar. The calculation of the savings or replacement costs is given in equation (2):

$$A = B - (B * c) + (D * e)$$

(Equation 2)

Where A represents the economy or cost in $kWh.t^{-1}$ cement, B the energy expenditure of tonne cement production in $kWh.t^{-1}$ cement, c the cement concentration in fraction, D the energy expenditure in the treatment of tonnes of sludge, in $kWh.t^{-1}$ sludge, and e the concentration of sludge in fraction.

Energy costs for sludge treatments, as well as for cement production, were obtained through studies by other authors. Table 1 shows these values.

Table 1: Energy demand for sludge preparation

Process	Electricity demand
Cement production	102 $kWh.t^{-1}$ cement [24]
Drum or fluidised bed dryers	0.07 $kWh.kg^{-1}H_2O$ [25]
Drying operation	39 $kWh.t^{-1}$ dry sludge [26]
Dry sludge and incineration	275 $kWh.t^{-1}$ dry sludge -1024.5 $kWh.t^{-1}$ dry sludge (recovery) [26]
Co-incineration	-250 $kWh.t^{-1}$ of dry sludge (recovery) [27]

Source: Authors

Results and Discussion

Sludge characterization

The sludge characterization showed that it has a pH of 7.8, moisture of 83.2% ± 0.2%, TS of 16.8% ± 0.2% and OM of 20.7% ± 4.4%.

The pH value between 7 and 8, indicates that it has not been chemically stabilized with liming products such as calcium carbonate [28]. The moisture of the sludge is similar to the values normally found in the literature [4]. The OM found is low and indicates that the processed sludge has been stabilized, and this is consistent with the neutral pH value found [13]. The TS is in agreement with the literature [29]. The TS and moisture are related to the efficiency of the dehydration process to which the sludge was submitted, in

this way, it can be said that the low value of OM is related to the good efficiency of the digesters.

Sludge preparation

From the M1 preparation methodology, it is assumed that all water has been removed, so the M1 moisture is 0%. Figure 1a shows the sludge in this methodology.

Apart from other points, the temperature of the environment influences the drying of the sludge during solar exposure. During the exposure time the average temperature for M2 was 14.1 °C with an average maximum of 18.2 °C and an average minimum of 11.5 °C. For M3 it was 21.3 °C with an average maximum of 23.6 °C and average minimum of 19.8 °C. Figure 1 (b,c) show the system formed for drying the sludge. After the exposure period the residual moisture of the sludge was 5.5% for M2 and 4.0% for M3. Figures 1d and 1e show the sludge before and after burning, respectively.

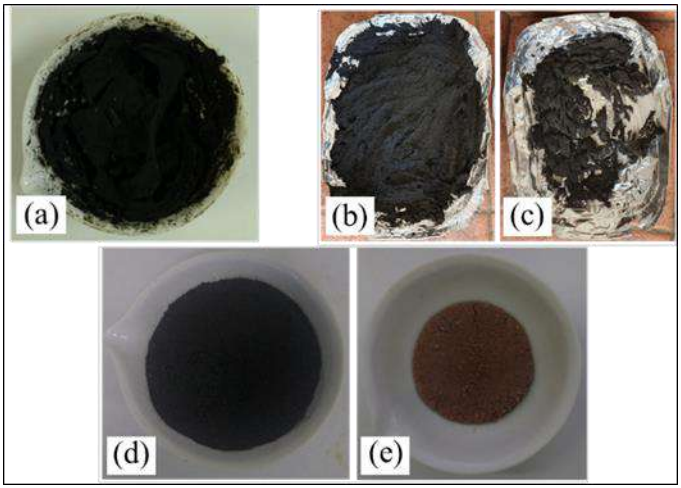

Fig 1: Sludge preparation for the different methodologies employed
Source: Authors

Mortar specimens

Mechanical tests

The tests intend to identify the changes that the incorporation of the treated sludge particles generate in the concrete mortar. Figure 2 represents the final flexural strength of the specimen for each methodology. Figure 3 shows the final compressive strength obtained by the specimen in each methodology. The vertical lines show the standard deviation in these measurements.

Analysis of variance was performed by simple ANOVA, considering each mortar preparation procedure and the concentration a different treatment for making the mortar, thus 38 observation points were analyzed at 19 levels. The homogeneous groups created according to Tukey's test are arranged by the lower-case letters in Figure 3.

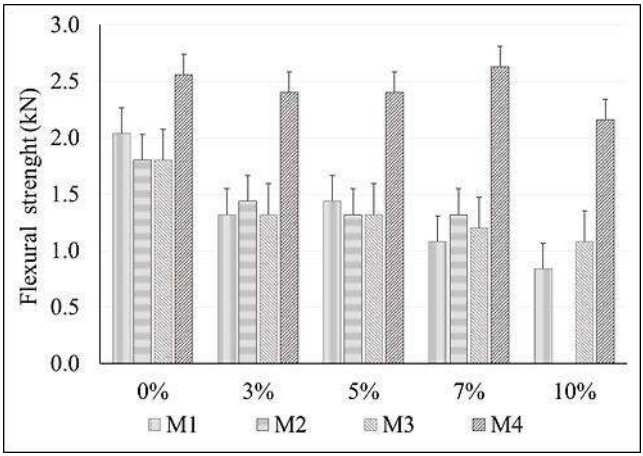

Fig 2: Flexural strength at 28-day age of curing acquired by the mortar for each treatment and substitution concentration.

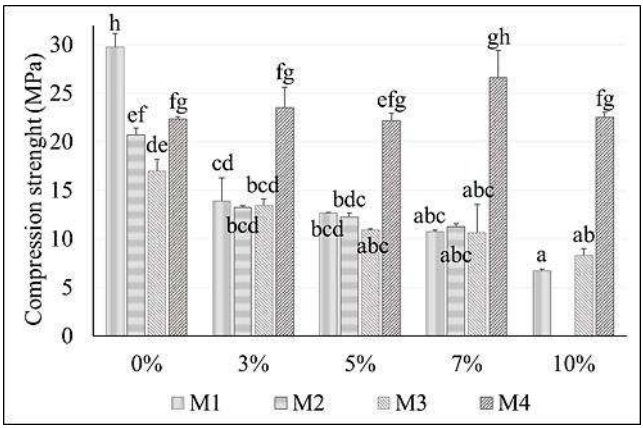

Fig 3: Compressive strength at 28-day age of curing acquired by the mortar for each treatment and substitution concentration and division of the mortars produced into homogeneous groups (Tukey multi-comparison test, $p \leq 0.05$)
Source: Authors

According to the results, only one of the specimens showed greater mechanical resistance compared to the standard, the specimen with 7% M4. The dry sludge specimens showed very similar values and behaviours, as the resistance drop profile and the resistance values.

Fonseca [30] also made mortar specimens replacing cement with dry sludge, but the author's results were different. For the 5% concentration, there was an improvement in resistance to both flexion and compression, compared to the standard [30]. The specimen with 10% concentration was very close to the standard in the flexural strength test, but in the compressive strength test, it showed a result 27% lower than the standard [30].

In Ingunza, Camarini and Silva da Costa's [31], the flexural and compressive strength of all samples obtained sludge ashes addition showed higher mechanical resistance than standard mortar. The author also replaced part of the cement mass for sludge ashes, however at concentrations of 0, 5, 10, 15 and 20%.

Although the increase in the sludge particles concentration decreases the flexural strength of the specimens, the concentration that shows the best results was 5% for dry sludge (M3 and M1). In the work of Fonseca [30] the best results of flexural strength were obtained with a concentration of 5%, too. In contrast to M4, the ideal concentration was 7%. In Ingunza, Camarini, and Silva da Costa's [31], the greatest flexural strength was obtained with 20% ash, however tests with higher concentrations were not carried out to conclude whether this is the ideal maximum concentration.

The deviation of the standards for each methodology may be due to changes in the cement due to the form of bag storage after opened, as well as irregularities in the quality of the sand used.

Two additional statistical analyses were performed on the compressive strength data. In one of the analyses the sludge concentration was disregarded, and the data were only processed by the mechanical resistance acquired according to the treatment of the sludge. In another scenario, the analysis was conducted disregarding the preparation method so that the data were treated by the mechanical strength and the slurry concentration in the mortar. The homogeneous groups formed from Tukey's test are shown in Table 2 by the lower-case letters.

Table 2: Homogeneous groups identified by Tukey multi-comparison test ($p \leq 0.05$) within which there are no statistically significant differences

Treatment	Average (MPa)	Concentration (%)	Average (MPa)
M3	10.81 a	10	12.52 a
M1	11.00 a	5	14.50 ab
M2	12.26 a	7	14.80 ab
M4	23.70 b	3	16.02 ab
		0	22.45 b

Source: Authors

Regarding the drying methods (M1-M3), they are similar as they are part of the same homogeneous group (a). M4 proved to be a highlighted method as it obtained the highest average resistance in a distinct homogeneous group.

The analysis of the influence of the concentration of cement replacement by the treated sludge, fourth column of Table 2, showed that concentrations from 3 to 10% are significantly similar (all belong to the same homogeneous group-a), however, the 10% replacement was the only one that did not resemble the standard (0%).

Dry sludge (M1-M3)

Combine the residual moisture data from the sludge drying methods, the mechanical resistance of the mortar and the homogeneous groups obtained shows that drying the sludge in the sun does not confer chemical alterations to the material, since what changes, from one formulation to another is the moisture content of the particles. This discussion shows that, in the possibility of drying the sludge in the sun, there is no variation in the quality of the mortar obtained in relation to the same mortar produced with oven dried sludge, as long as the system formed contributes to the efficiency of the drying process and that the climatic conditions are favourable.

All mortars with dry sludge particles have a compressive strength greater than 6 MPa, therefore they are all of the category CS IV. In this case the mortar can be applied in general purpose rendering/plastering mortar, in coloured rendering mortar and in one coat rendering mortar for external use, but in these applications, it is also necessary to determine other parameters such as dry bulk density, adhesion, capillary water adsorption and others [23].

Sludge ash (M4)

For M4 particles, all mortars produced are classified as CS IV [23].

According to the research conducted by Paschoalino *et al*. [32] cement does not harden by drying, but by chemical hydration reaction. Several factors influence the mechanical strength of mortars, the quality of the clinker, the water/cement ratio, the content and quality of the aggregates and the dosage of hydroxide calcium [32].

Burn sludge at 900 °C, according to Lynn *et al*. [9] increases the amorphous content of the final solid material, which increases pozzolanic activity. The increase in pozzolanic activity is related to the formation of oxides during burning, and the main ones in M4 are silicon oxide, aluminium oxide and calcium oxide [9]. The pozzolanic activity consists of binding lime in the presence of water, which results in the formation of water-insoluble

calcium silicates [13]. Thus, although the addition of sludge negatively influences the fluidity of the mixture, by absorbing water and extends the hardening time, it can contribute to increasing the compressive strength of the mass [13].

Hagemann *et al*. [20] evaluated the strength activity index to study the pozzolanic activity of the WWTP ash in the replacement of cement in mortars. The authors observed that there is a maximum percentage of the incorporation of the sludge ash from WWTP, which starts from the compressive strength decreases.

Aishwarya and Suresh [33] replaced part of the cement and fine aggregate with rice husk ash and waste foundry sand in the production of concrete. In their results, the compressive strength in the replacement with 10% rice husk ash revealed a peak of greater resistance in compared to the standard and concentrations of 5, 15, 20 and 25%. In Fonseca's [30], the peak compressive strength occurred at 5% of cement replacement by sludge ashes in mortars. In the work of Kaish *et al*. [34] the peak was 15%. In Naamane *et al*. [35], the peak was 5% for mortars with ashes prepared at 700 and 800 °C.

Considering the experiences of the authors mentioned above, the form of cement hardening highlighted by Paschoalino *et al*. [32], and the conclusions of studies carried out by Hagemann *et al*. [20], the peak mechanical resistance at 7% of cement replacement by sludge ash may represent the ideal replacement concentration.

Conclusions

The mechanical quality of mortar specimens with the incorporation of WWTP sludge was tested, thus studying the technical feasibility of the practices. From the comparison of energy production costs, between the cement production and the methodologies for preparing sludge for subsequent application in mortars, the economic valuation of practices was also evaluated.

From the discussions of energy expenditure, the characteristics of the sludge collected at the Bragança WWTP presents great potential for application in construction materials. The low content of moisture and organic matter contributes to the energy saving of sludge preparation processes, whether in incineration or drying.

The use of sludge ash in small concentrations does not alter the mechanical strength of the mortar, in the concentration of 7% substitution of cement for ash the mechanical quality increases in comparison with the standard mortar.

Between sun and oven drying there is no change in the quality of the mortar produced, but the moisture in the sludge does. The incorporation of the

sludge reduces the mechanical strength of the mortar in relation to the standard mortar, however even in concentrations of up to 10% this loss of strength does not make the mortar to be classified at a lower resistance than the standard mortar.

The practices of burning and drying the sludge obtained results that justify the procedures and the subsequent application in the mortar with potential of energy savings.

Based on these results wastewater treatment plant sludge performed well as a resource to produce eco-friendly mortars, incorporating sustainability in civil construction and extending the sludge's useful life in a safe and stable destination.

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Chapter - 11
Eutrophication: Source, Consequences and Restoration

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Chapter - 11

Eutrophication: Source, Consequences and Restoration

Sanjaya Dalai, Aparna Mishra, Alija Priyadarshini and Amit Kumar Mohapatra

Abstract

The development of science and technology in the last couple of centuries led to a population explosion across the globe, leading to increasing urbanization. In order to fulfil the uprising's food demands, cultivation on a large scale using huge amounts of artificial nutrient supplements with limited land resources became an unavoidable situation. Some of these nutrients enter the biological system and some flow to nearby water bodies. This unwanted nutrient loading on the water bodies makes them nutrient-rich. Urban sanitation and industrialization also added problems to the existing situation by releasing nutrient-rich polluted waters into water bodies and making them toxic as well. However, despite extensive research during the past few decades, there are few solutions to eutrophication. This review will highlight various sources of eutrophication and its impact and will try to connect solutions for the betterment of the future.

Keywords: Cultural eutrophication, urbanization, industrialization, nutrient supplements

Introduction

Eutrophication is the result of nutrient enrichment in water bodies, which leads to a rapid increase in algal growth that adversely affects aquatic life. Nutrient enrichment mainly indicates the increase in the level of both phosphorus (P) and nitrogen (N) in water. The increment in biomass of phytoplankton and macrophyte deteriorates water quality and disturb aquatic ecosystems (Farley, 2012). The main consequence of the process is reduced plant diversity and enhanced growth of a particular type of harmful algal derivatives. The plant growth on the water surface block sunlight penetration for submerged plants and algae causing the decaying of plant materials leading to highly increase in organic matter which accelerates hypoxia condition and the emission of toxic gases like methane and hydrogen sulfide. This type of disturbance in the aquatic environment makes it unusable for

drinking, agriculture, industrial even recreational purposes (Carpenter., 2005).

Eutrophication can happen in both freshwater and saltwater systems. In freshwater ecosystems, an excess of phosphorus is usually responsible for it. On the other hand, the main contributing nutrient in coastal waters is nitrogen or phosphorus and nitrogen together. It has been experimentally demonstrated that algal biomass production is usually due to phosphorus concentration in the water, while bigger algal biomass depends on total phosphorous (TP) to total nitrogen concentration (TN) (Conley *et al*., 2009). High TP: TN ratio leads to higher primary production (high phytoplankton growth) (Dodds *et al*., 2016).

Cause of eutrophication

Based on the duration of causing Eutrophication, it is mainly categorized into two types,

- **Natural eutrophication:** It is a slow process wherein nutrients and other types of organic matter are deposited in a basin and get accumulated in water bodies permanently or temporarily.

Estuaries are naturally eutrophic and highly productive since they receive nutrients from watersheds and due to tidal currents from upstream regions. In addition, lakes drove under the same category, as they are large, store sediments and organic matter and take time to become rich in nutrient concentration (Engelhardt *et al*., 2011).

- **Cultural eutrophication:** It is due to human activities and hence are more rapid process (Schindler *et al*., 2016).

According to the source, eutrophication is again divided into two types;

- **Point sources:** Nutrients are derived mainly from industrial effluents and sewage treatment plants and from fish farms (Geletu, 2023).
- **Non-point sources:** These indicate diffuse sources, including runoff from agricultural land using excess fertilizers, overflow from septic tanks, livestock manure and leakage from sewers (Farley, 2012).

Besides TP: TN concentration, silica is also concerned with eutrophication up to some extent (Dauvin *et al*., 2008). Other factors like reduced current velocity, required temperature, the activity of microbes and biodiversity are sources of natural eutrophication (Li *et al*., 2002).

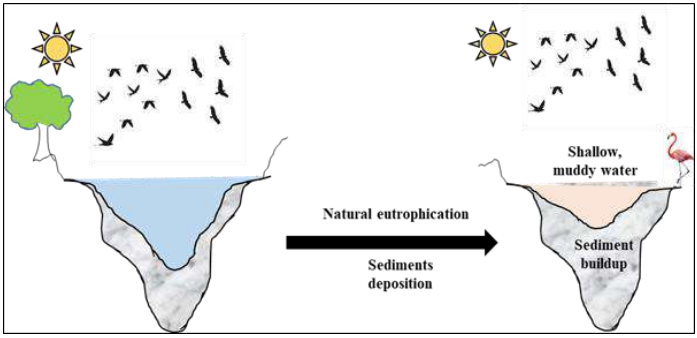

Fig 1: Natural eutrophication leading to the death of lake

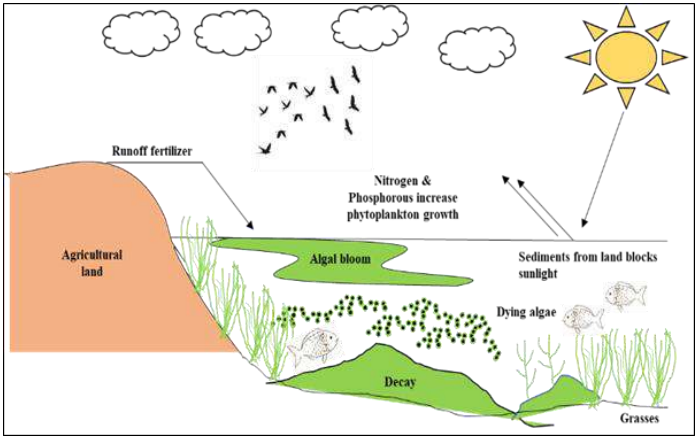

Fig 2: Eutrophication in water bodies due to agricultural runoff nutrients

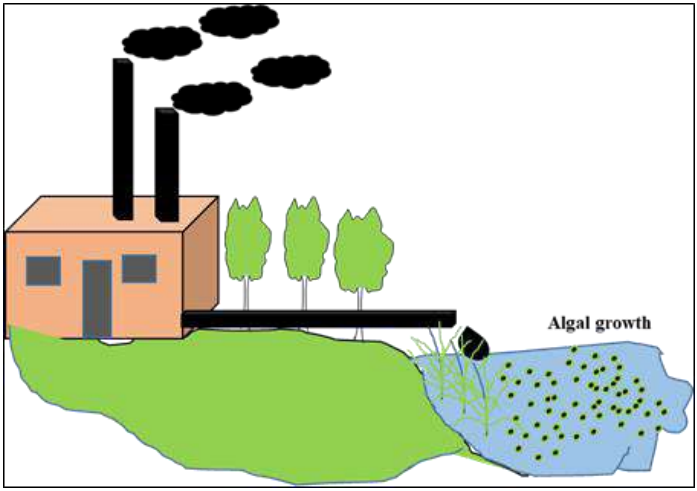

Fig 3: Eutrophication in water bodies due to industrial waste

Comparing lake to river eutrophication

Due to slit inputs, the lakes become shallower and the nutrients, which are, coming were distributed in a smaller volume of water, hence increase in the concentration of nutrients results in the biomass of algae. That is why the lakes are naturally more eutrophic with time (Eminson *et al*., 1980). The rate of eutrophication accelerated due to population growth, leading to macrophyte-dominated clear water being replaced by turbid or brown, green and blue-green coloured water.

Based on nutrient availability lakes are categorized (Mattson *et al*., 2004).

Oligotrophic: Nutrient-poor water.

Mesotrophic: Waters moderately enriched with nutrients.

Ultra oligotrophic: Extremely nutrient-deficient water.

Hypertrophic: Excessively nutrient-rich waters.

Limiting nutrients amount that is the proportions of carbon, nitrogen and phosphorus are essential for the growth of diverse phytoplankton groups. All the nutrients should be present in their optimum concentration that allows sufficient growth of cells, while if the amount of one or more nutrient drop below their concentration will hamper the increase in biomass (Hilton *et al*., 2006).

Retention time, which determines how long it takes to algae to use their nutrients fully, however, this period varies according to the flushing rate of the lake. If the lake flushing rate is faster than the algal growth rate, then despite nutrient loading algae are unable to grow likewise because large amounts of algae and nutrients would be washed out via the outflow.

However, in the river system, some evidence suggests that phosphorus has a significant role in macrophyte community structure (Dawson *et al*., 1999) a number of sites also there where phosphorous and nitrogen jointly behave as limiting factors for algal growth (Matlock *et al*., 1998). Nutrient-limiting growth probably changes depending on the plant types like macrophyte, epiphyte, and benthic algae.

Planktonic biomass will increase along the whole length of the river but at the upper reaches, algal biomass never reaches up to nuisance concentrations because the high rate of flushing at the source of the river is not beneficiary for the growth of planktonic algae.

Conversely, large and deep rivers have long retention time than the growth rate of algae cells hence a large biomass of phytoplankton can develop in the middle and lower reaches of the river.

Fig 4: Eutrophication in water bodies
https://www.google.com/maps/place/Kheras+UP+School+Rd,+Kheras,+Odisha+754018

Fig 5: Eutrophication leading to the death of water bodies
https://goo.gl/maps/jgBDahr9uYrscu7Y6

Factors affecting eutrophication

Nutrient enrichment

Several opinions are there in relation to nutrient loading to eutrophication. In low phosphorous concentration, it acts as a limiting factor for promoting eutrophication along with algal bloom. In high concentrations of phosphorous, several other factors like pH, depth of water, temperature, light, wave, or other bio factors may become limiting factors. Because of the increase in the developmental level of society, the effect of N and P lasts for a longer duration (Zhao, 2004). The ratio of N: P, which is called as Redfield ratio is 16:1 then it, can act as a limiting factor (Redfield *et al*., 1963; Hodgkiss and Lu, 2004).

Source of nitrate: Nitrates can enter into natural waters from several sources.

Two major sources are:

- City sewage-Considerable bulk of human and animal wastes contain large amount of Nitrates.
- Agroecosystems-Fertilizers that run off from croplands and sub-urban lawns during rainstorms are rich in nitrates.

*The chlorophyll concentration can be strongly linked to the total nitrogen concentration.

Source of phosphorus

- Nearby cattle feedlots, hog farms, diaries and barnyards**.**
- Polyphosphates used in water treatment converted to orthophosphate when into the water body.
- Phosphate mining and processing.
- Forest fire and soil erosion.
- Agricultural runoff and domestic sewage.

Hydrodynamics

Water disturbance is not directly related to eutrophication, but indirectly it influenced by changing light and nutrient status. In case of shallow water, more disturbance in water leads to more release of P from sediments, at high temperature (Cai *et al*., 2007). Tide also influence the multiplication of algal bloom by assembling nutrient concentration. Wave height below 30 cm bring no significant change in top layer water quality but it increase suspended solid concentration at bottom layer (Zhu *et al*., 2007).

Environmental factors

In many moderately eutrophicated water bodies, algal bloom occurs in some seasons or some years according to the promising environment. Algal bloom modifies several abiotic factors of the water body, which directly govern the growth, diversity and density of the biotic components.

Temperature and salinity are two major factors that affect eutrophication. Algal bloom prefers a range of temperature between 23 ^{o}C to 28 ^{o}C and salinity between 23% to 28%. Variation in this range affects the growth of algal blooms up to a certain extent (Wang *et al*., 1996).

For example, the process of sporangium germination is hypersensitive to temperature, while the average temperature in winter is highly relative to the beginning growth of gymnodinium (Yang *et al*., 2008). Similarly, Salinity is

influenced by nutrient concentrations. It is negatively related to NO_3^- and PO_4^{3-}, but positively related to NH_4^+. The influence of temperature on algal bloom growth rate is high, followed by salinity and their interaction.

Carbon dioxide: Cyanophytes are more capable of utilizing low levels of carbon dioxide which keeps them at the upper layer of water surface with abundant sunlight. This type of dense vegetation inhibits sunrays to penetrate lower levels of water and it affects the swimming of zooplankton. This leads to a condition of a slow-moving freshwater ecosystem, which is rapidly dominated by blue-green algae.

Light: Algal growth increases with light intensity. Luminescence of 4000 lux is the most favourable. In densely eutrophicated water, the light gets completely absorbed by the plankton at the top few meters, so that little light penetrates to thermocline and beyond to support photosynthesis. The reduction in sunlight penetration inhibits submerged and rooted macrophyte growth and sediment became anoxic (Kant *et al*., 1990).

Dissolved oxygen: Maximum and minimum concentration of phytoplankton is directly related to the maxima and minima in the concentration of dissolved oxygen (Khan *et al*., 2005).

pH: The change in the pH level of water is directly related to the availability and absorption of nutrients from solutions. An acidic pH promotes the growth of *Spirodela polyrhiza* while high pH promotes the growth of phytoplankton ultimately resulting in bloom.

*It must be noticed that each factor that influences eutrophication relatively affects each other.

Microbial and biodiversity

Microbial biomass is positively correlated with the organic matter concentration and phytoplankton mass in eutrophicated water. The decomposition of organic matter by microbial activities enhances nutrient enrichment of the aquatic system, which promotes algal bloom breaking out. Some algal blooming also produces some toxic substances, which will be harmful to other algal species but some specific groups get beneficial environments and get dominated.

Bioindicators of eutrophication

Also known as “Ecological indicators”. These are used to observe the functioning and cause-effect relationship within an ecosystem. The diversity and distribution of a species mainly depend on the ecological amplitude of a present species in addition to its ecological environment. Bioindicators are

different in river systems than in lakes. In river bio indicators means the diversity and occurrence of the life cycle along with its dimensions, while in lake ecosystem bio indicators comprises; the area and biomass of macrophyte that ultimately indicate the turbidity rate and the ratio between prey and predator fish which is to be 1:1 to 2:1 that confirm the purity of the lake (Lorenz., 2003).

Some biotic components have been used as biological indicators of eutrophication.

Algae: Eutrophication causes a remarkable change in the biomass of algae in lakes and reservoirs, streams and rivers, wetlands and coastal marine ecosystems (Smith., 2003). At the site of the point source diversity decreases, but *Ulva lactuca*, a seaweed-like lettuce was found in abundance (Rogers, 2003).

Macrophytes: Some Species like *Wolffia arrhiza, Lemna gibba, Ceratophylum demersum* were reported to be best indicators of eutrophication caused by organic effluents and nutrients (Stojanovic *et al*., 1998). Growth of *Spirodela polyrrhiza* was directly connected to the nutrient concentration (Ansari & Khan, 2002). Growth of Limna minor and *Spirodela polyrrhiza* caused by household detergents (Ansari, 2005).

Diatoms: Phosphorus considered as the main source of increased diatom production (Foy *et al*., 2003). Nutrient supply from sewage and agricultural sources brings changes in geochemistry and diatom assemblages hence increase in primary production (Gibson *et al*., 2003). Biological analysis show there is little difference in diatom population in upstream and downstream of sewage treatment plant, however chemical analysis showed that nitrogen acted as a limiting factor (Kelly & Wilson., 2004).

Plant pigments: Phytoplankton photo-pigments are indicators of estuarine and coastal eutrophication. In addition, chlorophyll a was suitable as a biological indicator in eutrophicated lakes and correlates with nitrogen and phosphorus (Wei *et al*., 2000; Kufel, 2001).

Effects of eutrophication

The increasing rate of decomposition of organic matter cause hypoxia and anoxia conditions which are dependent on the turbulence of the system. A major community reaction was seen as the loss of K-selected (intolerant) species and an increase in the r-selected species i.e. opportunists fauna is the result of organic matter degradation in a large-scale manner (Jonge *et al*., 2002). Gradually the long-living and slow-growing species were replaced by

the opportunist species like *Enteromorpha, Ulva, Cladophora* etc. This change in the composition of species forms dense layers, which causes oxygen scarcity and high degradation leading to anoxia conditions (Raffaelli *et al*., 1998). Based on variations in the affinity of algae to nutrients, changes in nutrient ratios cause a change in algal species composition. A result of which occurrence of toxins (e.g., microcystin and anatoxin-a) producing noxious blooms brings harsh effects to that water system. Harmful algal blooms very commonly produce several neurotoxins that increase the rate of fish death and affect organisms with complex nervous systems.

Low turbid systems may change from macrophyte-dominated water to phytoplankton dominated one and in case of high turbid the situation is different because of light limitation to the benthic zone which gets devoid of vascular plants like eelgrass and large brown algae. Both conditions negatively influenced the integrity of the systems. Ultimately, habitat loss, poor water quality and deterioration of the marine environment make it worst for the purpose of human use.

Toxin-producing cyanobacteria, like Anabaena, Cylindrospermopsis, Microcystis and Oscillatoria show dominancy in nutrient-rich, low N/P ratios, low light levels and in case of high temperature (Paerl *et al*., 2012). Cyanobacteria are also found in municipal drinking water systems as well as in aquaculture, resulting in large financial losses (Crews *et al*., 2007). In laboratory studies (Wilson *et al*., 2006) (Tilmanns *et al*., 2008) it has been found that cyanobacteria have been shown to be poor quality food for most zooplankton grazers, hence lowering the efficiency of energy transfer in aquatic food webs.

Statistical exploration of eutrophication

When nutrients, especially nitrogen and phosphorus, are added in excess to a body of water like a lake or river, eutrophication occurs. Any biological process occurring in nature always depends on various factors. Thus in order to understand the process, it is always essential to have knowledge of the role of each factor involved. Each factor of eutrophication can be analyzed using biostatistics and explained in the model.

Here are several steps for studying eutrophication using biostatistics:

Data collection and sampling: Biostatisticians are essential in developing sample plans to gather information on algal blooms, nutrient concentrations, water quality indices and other pertinent factors. To ensure representative data, they can choose the right sample size and locations for sampling.

Descriptive statistics: To summarise and describe the gathered data, biostatistical methods are applied. To comprehend the central tendency, variability, and distribution of nutrient concentrations and other factors connected to eutrophication, measures such as mean, median, standard deviation, and percentiles can be calculated.

Time series analysis: Eutrophication is frequently a dynamic process that happens over time, according to time series analysis. To find trends, patterns, and seasonal fluctuations in nutrient concentrations, algal growth, and other indicators of eutrophication, biostatisticians can use time series analytic techniques. Understanding the temporal dynamics and figuring out possible relevant elements can both be helped by this analysis.

Hypothesis testing: To find out if there are significant differences between various eutrophication-related metrics, biostatistics offers techniques for hypothesis testing. For instance, statistical analyses can be used to compare nutrient concentrations between different times or places, estimate the success of mitigation measures, or gauge the influence of certain treatments or management plans.

Regression analysis: Regression models can be used by biostatisticians to investigate the connections between nutrient concentrations and other variables. The main contributors of eutrophication, such as land use patterns, agricultural practices, or wastewater discharge, can be found using multiple regression analysis. Understanding the fundamental causes and foreseeing the effects of changes in these aspects are made easier with the help of this study.

Spatial analysis: The spatial distribution and trends of eutrophication within a region can be examined using geospatial tools and spatial statistics. To predict spatial variability, produce interpolation maps of nutrient concentrations, and evaluate the extent and intensity of eutrophication in various places, biostatisticians can use techniques like geostatistics.

Modelling and simulation: The development and improvement of mathematical simulations and models of eutrophication processes can benefit from the use of biostatistics. To forecast future and direct management choices, these models can incorporate numerous environmental and hydrological variables, fertilizer inputs, and biological interactions.

Scientists and decision-makers can better understand the causes, trends, and effects of eutrophication by using bio-statistical approaches to the study of this phenomenon. This will help them create more effective preventative and mitigation plans.

Large-scale modelling of eutrophication processes can be employed to gain advanced scientific knowledge.

Model calibration

Models can be used for representations of aquatic systems. Water quality data are highly variable, so individual equations that are approximately correct in ideal (controlled laboratory) conditions may not collectively yield an accurate picture of ecosystem behaviour. Thus, each entry and exit path of the model must be correctly analysed and gathered data must be provided to the model system properly. The very first-time eutrophication modelling and management were discussed by Hornberger and Spear in 1981, which suggested the use of localized methods of estimation that provide parameter distributions rather than single values (point estimates) as a remedy for the lack of comprehensive data sets (Arhonditsis *et al*., 2008).

For example, a lake ecosystem is represented in a model. All components of the lake were taken into consideration and represented as individuals. Phosphate (PO4)-detritus (DET)-phytoplankton (PHYT)-zooplankton (ZOOP). Arrows in the model indicate flows of matter through the system (Arhonditsis *et al*., 2008).

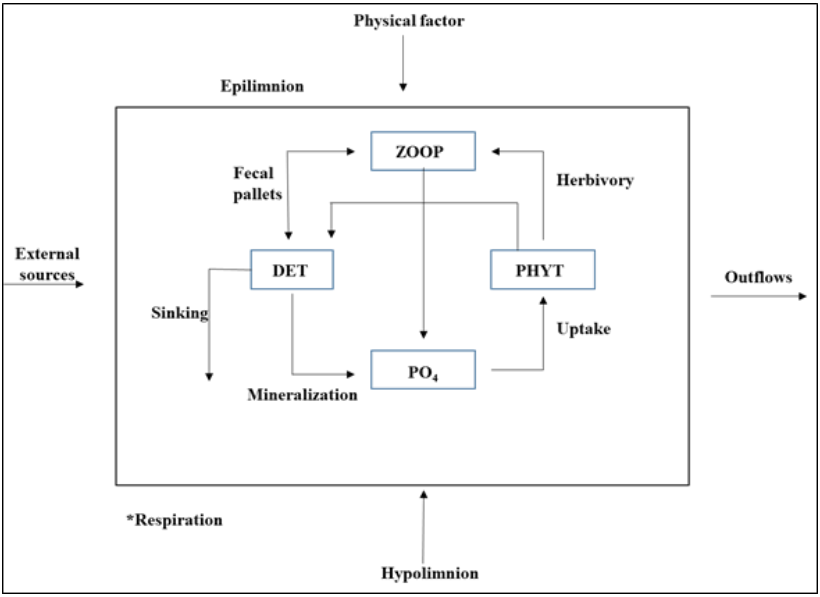

Fig 6: A Lake ecosystem is represented in a model showing the flow of nutrient matter through the system

Control of eutrophication

The average concentration of phosphorus in wastewater is in the range between 10-20 mg L^{-1}. Common forms of phosphorus in wastewater are orthophosphate, composed of about 50%-70% phosphorus. Phosphorus is the major factor responsible for the growth of algae. The algae growth can be controlled by reducing the input of any one of the essential nutrients. In freshwater lakes and rivers, phosphorus is the limiting nutrient as it is found in lesser quantities that are required for optimum plant growth (Reutter, 1999). Excessive amounts of phosphorus and nitrogen when added to the water system will lead to a makeable growth of bloomed algae. Removal of those phosphorus-bound algae before the anoxic state of the bottom may help to control eutrophication up to some extent.

Biological control

Aquatic macrophytes like *Eichhornia crassipes* and *Salvinia auriculata* cause significant reduction of nutrients from water (Petrucio *et al*., 2000). Some aquatic weeds like Typha, Phragmites and Glyceria sp. are useful in removing nutrients from the eutrophicated body (Beltman, 1990). Seaweeds can remove up to 90% of nutrient discharge from intensive fish farms (Luning *et al*., 2002). Constant harvesting of macrophytes would be necessary to manage eutrophication (Wychera *et al*., 1990). Water hyacinth can be used for the potential removal of particulate matter and nitrogen (Billore *et al*., 1998).

Water peanut, *Alternanthera philoxeroides*, improves the transparency of eutrophic lake water (Wang *et al*., 1999). Dissolved phosphorus can be removed in irrigation drainage water by floated plants (Wen *et al*., 2002). Aerial macroalga *Trentipohlia aurea* removes characteristics of nitrate, nitrite, ammonium and phosphate ions (Abe *et al*., 2002).

Role of microorganisms: Several microorganisms are reported to be efficient scavengers of phosphates from sewage. For example, a bacterium *Acinetobacter calcoaceticus* removed phosphate from an acetate medium-based plant (Lawson *et al*., 1980).

Mechanical control

Increased capacity and improved sewage treatment are the most effective way to reduce phosphorus concentration. Municipal sewage-treatment plants discharge more than 1 million gallons of sewage water. Phosphate in these plants can be precipitated from the sewage before mixing with an aquatic body. The eutrophication process also be controlled by the

direct killing method. Copper sulfate and sodium arsenate are employed for killing algae and rooted plants respectively (Khitoliya, 2004).

Conclusion

Despite continuous efforts to improve water quality under the clean water and safe drinking water act, 1970 cultural eutrophication and naturally associated HABs are continuously causing water pollution in near fresh water and marine coastal waters (Smith & Schindler, 2009). Water reserves near large cities receive more nutrients (phosphorus) from domestic sewage containing detergents, while urban areas discharge more phosphorus from fertilizers and agricultural-related activities. Control and management of cultural eutrophication will require collective efforts of scientists, policymakers and citizens to develop long-term bio-manipulation techniques to restore aquatic communities (Chislock *et al*., 2013). Comprehensive guidelines should be put forward by taking various factors into consideration especially maintaining safe sides for modern society's ecology and health.

By completely understanding the factors associated with it that are mainly responsible for eutrophication, we can manage the purity of water bodies up to a large extent. Awareness programs by govt. and non-govt. organization can help to overcome this problem. Efforts should be made at the international level to produce phosphorus-free detergent. Essential steps should be taken at all local levels to be aware of this issue and follow necessary actions taken by high authorities to combine eradicate the water issue.

Author contributions

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Conflict of interest

No conflict of interest among authors.

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