IEHE is an 'A+' Grade Center of Academic Excellence established by the Government of Madhya Pradesh. It has been a harbinger of progressive and incremental changes in the portals of higher education, setting new benchmarks for other institutions in the state to redefine the precincts of scholastic and holistic development.

The Institute has been recognized twice as a Center with Potential for Excellence by the University Grants Commission, and as a Center of Cluster for Enhancing Quality through Innovation and Collaboration by the Government of Madhya Pradesh.

Design & Graphics

SCHOLARS PARK

Published : 03 December 2023

IEHE

THE QUEST

A Biannual Multidisciplinary Refereed Journal

VOLUME - 2

2023

Institute for Excellence in Higher Education

Kolar Road, Kaliyasot Dam, Bhopal - 462 016 Madhya Pradesh, India

Contact us

PUBLISHER
Institute for Excellence in Higher Education
Kaliyasot Dam, Kolar Road Post Box No. 588, Post Office
Ravishankar Nagar, Bhopal - 462016
Website: www.iehe.ac.in | Email: iehequest@gmail.com
Contact Nos. 0755-2492433; 9926320428

CHIEF EDITOR

Dr. Hari Krishna Garg
Professor | Department of Biotechnology
Institute for Excellence in Higher Education
Kaliyasot Dam, Kolar Road Post Box No. 588, Post Office
Ravishankar Nagar, Bhopal - 462016
Email: drharikrishna.garg@mp.gov.in
Contact No. 9424417792

Editorial Board

About the Journal

IEHE The Quest is published twice in a year by the Institute for Excellence in Higher Education, Bhopal, India. The authors are solely accountable for the text and illustrations published in the research journal, and IEHE The Quest, its publisher or its editorial members do not owe any responsibility for the content.

Journal Particulars

Title	**IEHE The Quest**
Frequency	Two in a year
ISSN No.	Awaited
Publisher	Institute for Excellence in Higher Education, Bhopal
Chief Editor	**Dr. Hari Krishna Garg**
Copyright	Institute for Excellence in Higher Education, Bhopal
Starting Year	2022
Subject	Multidisciplinary
Languages	Multiple Languages - English & Hindi
Publication Format	**Online**
Phone No.	0755-2492433
Email ID	**iehequest@gmail.com**
Mobile No.	9926320428
Website	www.iehe.ac.in
Address	**Institute for Excellence in Higher Education,** Kaliyasot Dam, Kolar Road Post Box No. 588, Post Office Ravishankar Nagar Bhopal - 462016

Index

To evaluate the water quality index and suitability of drinking water in Institute for Excellence in Higher Education (IEHE) Bhopal, M.P.

Akhilesh Shende and Anjali Acharya

Department of Chemistry
Institute for Excellence in Higher Education (IEHE) Bhopal, M.P. India

Abstract

The present study aims to evaluate a range of hydrological parameters, including dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), alkalinity, total dissolved solids (TDS), hardness, conductivity, pH, as well as concentration of chloride, fluoride, iron, ammonia at five distinct sites of the institute. These findings were subsequently compared against the water quality standards set by the World Health Organization (WHO), the Indian Council for Medical Research and the Bureau of Standards of India (BIS). All the aforementioned set of parameters were measured and the result was aggregated into a single number representing the overall quality of water. It was worth noting that the overall water quality at all the sites remained within the safe limits. The systematic calculation of correlation coefficients (R) among various physicochemical parameters enabled the comparison of water quality across different locations and offered insights into prioritizing necessary treatment for specific sites.

Keywords: *Water quality, physicochemical parameter, correlation, IEHE, Bhopal.*

Introduction

The global significance of surface water quality cannot be overstated, as it plays a vital role in driving socioeconomic progress, sustaining agriculture, fostering robust ecosystems, and safeguarding human well-being. [1], [2]. The degradation of water resources can be attributed to both natural processes and human activities.[3], [4]. Access to an optimal quantity and ensuring an acceptable quality of water is fundamental for survival. However, maintaining this acceptable water quality poses a significant challenge within the field of water resources management [5]. Evaluating the quality of water bodies involves assessing changes in their physical, chemical, and biological characteristics, which can result from both natural processes and human activities [6]. Consequently, the assessment of water quality in specific water bodies relies on the measurement of physical, chemical, and biological parameters, often referred to as variables. This involves the collection of samples and data at specific locations [6],[7]. To address this need, the suitability of water sources for human consumption is often expressed using the Water Quality Index (WQI). The WQI is a powerful tool that condenses a wealth of information into a single value providing a concise overview of water quality conditions [8].

Institute for Excellence in Higher Education is an ‘A+’ grade state-level academy, envisioned to be a center for academic excellence by the Govt. of Madhya Pradesh since its inception in 1995. Located in a lush green valley adjacent to Kaliasot Dam on Kolar Road, Bhopal, this educational oasis enjoys a pride of place amongst the country's premier Institutions. Students belonging to different parts of Madhya Pradesh and India have been enrolled in the institute. The water quality is kept in check owing to the good health of almost 3000 students visiting daily and over 200 students permanently residing in the hostel of the campus. Water makes up about 60% of human body weight. Therefore, a supply of high-quality drinking water is essential for the proper functioning of the mind, heart and other vital body functions. In the present study, different samples of water were collected from five different locations of the institute.

Figure-1: Satellite map showing the location of Institute for Excellence in Higher Education Bhopal M.P.

The prime objectives of the present study were:

1. Selection of water quality parameters to be measured - It depends on the purpose of the WQI assessment. Some common parameters for drinking water analysis are DO, BOD, COD, alkalinity, TDS, hardness, conductivity, pH, chloride, fluoride, iron and ammonia.
2. Collection of drinking water samples from different areas of the campus.
3. Analysis of the above-mentioned physicochemical parameters by different methods.
4. Comparison of the analyzed data with standard values recommended by the World Health Organization (WHO), Standards and Indian Standard (BIS) and Indian Council of Medical Research (ICMR).
5. To Calculate the Water Quality Index (WQI) and find out the nature of the relationship between the water quality parameters using correlation analysis.

Material and Methods

Correct sampling and storage are critical for accuracy in results. Each sample to be tested was collected keeping in mind the necessary precautions. Proper steps were taken to minimize any contamination which could be a result of human error.

Water samples from five different locations were collected, preserved and analyzed for various physicochemical parameters such as DO, BOD, COD, alkalinity, TDS, hardness, conductivity, pH, chloride, fluoride, iron and ammonia. These samples included water from five different tube wells which serve as the main source of water for the college campus. Samples from water purifiers installed - Sample-1 (Dr. APJ Abdul Kalam Boys Hostel), Sample-2 (Ojaswini Girls

Hostel), Sample-3 (Administrative Block), Sample-4 (New Academic Block), Sample-5 (Science Block).

Figure-1 Satellite map showing locations of water sampling points (Details of sample codes as in material and methods)

Physiochemical Analysis

The collected samples were tested and analyzed for various physicochemical parameters such as DO, BOD, COD, alkalinity, TDS, hardness, conductivity, pH, chloride, fluoride, iron and ammonia. The different methods to examine the different physicochemical parameters are shown in **Table 1**

Table 1 Methods used to examine the physicochemical parameters of water samples.

S.No,	Parameters	Method
1	DO (mg/l)	Electrochemical Probe
2	BOD (mg/l)	Incubation
3	COD (mg/l)	Titrimetric
4	Alkalinity (mg/l)	Titrimetric
5	Chloride (mg/l)	Gravimetric
6	Hardness (mg/l)	Titration
7	Conductivity (µS/cm)	Conductometric
8	pH	pH metry
9	Fluoride (mg/l)	Spectrophotometric
10	Iron (mg/l)	Spectrometric
11	Ammonia (mg/l)	Spectrometric
12	TDS (mg/l)	Gravimetric

Water Quality Index

In this study, all twelve parameters were employed in the computation of the Water Quality Index (WQI). The assessment of the WQI was conducted in accordance with the drinking water quality standards established by authoritative bodies such as the Indian Council for Medical Research [9], the Bureau of Standards of India (BIS) [10], [11], and the World Health Organization [12]. The calculation of the WQI for different water samples was carried out using the weighted arithmetic index method, involving a series of sequential steps.

The Weighted Arithmetic Water Quality Index (WQI) method was used for the calculation of WQI. Initially introduced by Horton [13], this method was further developed by Brown et al. [14], and previously mentioned in [15]. The approach involves the multiplication of water parameters by weighting factors, and effectively categorizing water quality based on the most commonly measured water quality variables [7]. A notable advantage of this method is its tailored utilization for specific water assessments, simplifying comparisons with a reduced number of factors required which are easy to calculate and interpret. This WQI method serves as a valuable tool for evaluating water quality. Its implication does not require any complex mathematical or statistical knowledge.

$$\mathrm{WQI} = \frac{\sum_{x=1}^{n} W_x Q_x}{\sum_{x=1}^{n} W_x}$$

where Q_x is the quality rating and W_x is the unit weight for the x^{th} water quality parameter and n is the number of water quality parameters.

Brown et al. [14] proposed the calculation of Qx using the following equation

$$Q_x = \left[\frac{V_x - V_i}{S_x - V_i}\right] \times 100$$

where V_x is the estimated value of x^{th} parameters in a given water sample, S_x is the standard permissible value of x^{th} parameter and V_i is the ideal value of x^{th} parameter (0 for all, except pH = 7).

In this study, the unit weight (W_x) of different parameters is calculated using recommended standards. If the recommended standard for parameter x is S_x, then the unit weight (W_x) is

$$W_x = \frac{K}{S_x}$$

where K is the proportional constant, the value of K is calculated using

$$K = \frac{1}{\sum \frac{1}{S_x}}$$

For example, in case of pH, the ideal value is 7.00 and the permissible value is 8.5 and the water quality rating Q_{pH} is

$$Q_{pH} = \left[\frac{V_{pH} - 7.00}{8.50 - 7.00}\right] \times 100$$

where V_{pH} is observed value of pH. The standard and permissible values along with unit weightage for different physiochemical parameters as recommended by different agencies are shown in Table 2

Table 2 Standard, Permissible limit of parameters with recommended agencies and unit weightage

S.No.	Parameters	Standard	Permissible	Recommended Agencies BIS/ICMR/WHO	Unit Weightage
1	DO (mg/l)	0	5	ICMR	0.069902
2	BOD (mg/l)	0	5	ICMR	0.069902
3	COD (mg/l)	0	200	WHO	0.001748
5	Alkalinity (mg/l)	0	600	BIS	0.000583
6	Chloride (mg/l)	0	1000	BIS	0.00035
7	Hardness (mg/l)	0	600	BIS	0.000583
8	Conductivity (µS/cm)	0	3000	BIS	0.000117
9	pH	7	8.5	BIS	0.041119
10	Fluoride (mg/l)	0	1.5	BIS	0.233007
11	Iron (mg/l)	0	1	BIS	0.34951
12	Ammonia (mg/l)	0	1.5	WHO	0.233007
14	TDS (mg/l)	0	2000	BIS	0.000175

For this study, we have referred to the classification of water quality, as determined by the Water Quality Index (WQI) developed by Brown et al. [14], as well as the works of Amadi A et al. [8] These references and their corresponding details can be found in Table 3

Table 3 Water Quality Rating for Drinking

S.No.	WQI level	Water Quality Rating
1	< 50	Excellent
2	50 – 100	Good
3	100 – 200	Poor
4	200 – 300	Very Poor
5	> 300	Unsuitable for Drinking

The weighted arithmetic mean method employed in this study, as highlighted by Tyagi et al. [16], offers several advantages:

1. It integrates data from multiple water quality parameters into a mathematical equation, providing a quantifiable rating for the overall health of a water body.
2. Compared to considering all available water quality parameters, it demands a reduced number of parameters, streamlining the assessment process for specific applications.
3. It proves to be a valuable tool for effectively conveying comprehensive water quality information to concerned citizens and policymakers.
4. This method captures the combined influence of various parameters, making it particularly important for the assessment and management of water quality.

Correlation Coefficient

Correlation analysis serves as an initial descriptive method to gauge the strength of connections among multiple variables within the study. The correlation matrix we computed by us reveals the extent of linear associations between any two parameters, quantified by correlation coefficient (R). The R-value aids in identifying highly correlated and interrelated water quality parameters that may impact the overall water quality in the area. R-values range from -1 to +1, with an R value of +1 or close to it signifying the strongest positive linear correlation, while an R value of -1 or close to -1 indicates the strongest negative linear correlation. The most popular correlation coefficient is Pearson's, also called Pearson's R. The formula for Pearson's correlation coefficient is:

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{(x_i - \bar{x})^2(y_i - \bar{y})^2}}$$

r = correlation coefficient
x_i = values of the x-parameter in a sample
$\bar{x}$ = mean of the values of the x-parameters
y_i = values of the y-parameter in a sample
$\bar{y}$ = mean of the values of the y-parameters

Result and Discussion

This research involved the collection of water samples from five distinct locations within the institute, as illustrated in Figure-1. The following section provides details on the various parameters that were taken into account. In this study, we have utilized the drinking water standards outlined by the Indian Council of Medical Research (ICMR [9]), the Bureau of Indian Standards (BIS 2012 and 2015 [11], [10]), and the World Health Organization (WHO 2017 [12]) as our reference benchmarks.

Physiochemical Parameters

The observed values of water quality parameters from different sites of the institute are shown in the Table **4**. The statistical analysis of the physiochemical parameters is shown in Table **5**.

Dissolved Oxygen (DO)

Dissolved oxygen (DO) is a critical parameter in water quality and aquatic ecosystems, influencing the survival and health of aquatic organisms, especially fish. DO levels are affected by various factors like temperature, pressure, salinity, and the presence of photosynthetic organisms. Adequate DO is essential for aquatic life as it's required for respiration. Insufficient DO leads to hypoxia, harming fish and other aquatic organisms. Conversely, excessive DO can also harm aquatic life. Monitoring and managing DO levels are crucial for maintaining healthy aquatic ecosystems, especially in environments where natural processes and human activities can cause DO variations, such as lakes, rivers, and oceans, affected by pollution and nutrient runoff.

In this study the DO was found in the range of 0.4 – 1.0 mg/l, which showed that all the obtained values are within the permissible limit of DO as dictate by ICMR (5 mg/l).

Biological Oxygen Demand (BOD)

Biological Oxygen Demand (BOD) is a crucial parameter for assessing water quality in bodies of water such as rivers, lakes, and wastewater systems. BOD measures the amount of dissolved oxygen consumed by microorganisms over a specific period, typically five days (BOD5), as they decompose organic substances in the water. Elevated BOD levels indicate the presence of significant organic pollutants, often originating from sources like sewage, agriculture runoff, or industrial discharges, which serve as food for microorganisms and lead to oxygen depletion in the water, known as hypoxia or anoxia. Monitoring BOD is essential for evaluating water quality, enforcing pollution control measures, and safeguarding aquatic ecosystems. Lower BOD values indicate cleaner water with reduced organic pollution, while higher values suggest elevated pollution levels and increased environmental risks. The BOD can be strategically reduced by aerating water bodies, treating wastewater, managing industrial discharge and reducing the amount of organic matter entering the water bodies from farms because of various agricultural practices. It is often necessary to imply a combination of strategies in order to achieve the desired results.

In this study, the BOD was found in the range of 1.1 – 3.6 mg/l, which showed that all the obtained values are within the permissible limit of BOD as dictated by ICMR (5 mg/l).

Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) is a critical parameter for assessing water quality as it measures the amount of oxygen utilized for chemical oxidation by various organic and inorganic substances in water. It quantifies both biodegradable and non-biodegradable organic matter, along with specific inorganic compounds subjected to chemical oxidation. The COD test involves introducing a potent oxidizing agent, usually potassium dichromate, to a water sample under controlled heating conditions and measuring the oxygen consumed. It is expressed in mg/l. COD analysis is vital for environmental monitoring and wastewater treatment, offering insights into water pollution levels. Elevated COD levels indicate the presence of organic substances, including potential contaminants like industrial discharges, sewage, or agricultural runoff, which can reduce oxygen availability in aquatic environments, posing a risk to aquatic life and overall water quality. Monitoring COD is essential for regulatory agencies, environmental advocates, and industries to assess water quality, design effective wastewater treatment plans, and ensure compliance with environmental regulations. Addressing high COD levels often requires advanced wastewater treatment technologies and pollution control measures to minimize the adverse impact on aquatic ecosystems and human health.

In this study, the COD was found in the range of 25 – 185 mg/l, which showed that all the obtained values are within the permissible limit of COD as specified by the World Health Organization (200 mg/l)

Alkalinity

Water alkalinity is its ability to neutralize acidity, often due to the presence of substances like hydroxides and bases. In natural water bodies, common alkaline components include carbonates, bicarbonates, and hydroxides, with bicarbonate ions being the most prevalent. Alkalinity can arise from free OH^- ions and salts like carbonates and bicarbonates through hydrolysis. It indicates the water's capacity to counteract acidic solutions by binding hydrogen ions. High alkalinity is often associated with "hard" water, primarily attributed to calcium carbonate, which can originate from sources like limestone or leach from minerals in the soil. Carbonate and bicarbonate anions are the primary contributors to alkalinity. Alkalinity is typically expressed in milligrams per litre (mg/l).

In this study, the alkalinity was found in the range of 560 – 580 mg/l, which showed that all obtained values are below the permissible limit of alkalinity as dictated by BIS (600 mg/l).

Chloride

Chloride ions (Cl^-) are common anionic elements found in water, often bound to minerals like calcium, magnesium, or sodium to form compounds known as chlorides, such as sodium chloride (NaCl) and magnesium chloride ($MgCl_2$). Chlorine gas (Cl_2) is toxic in its elemental form and is used as a disinfectant. However, when combined with elements like sodium, it becomes essential for life and plays a role in the cellular functions of both plants and animals. While chlorides are generally not harmful to human health, the sodium component in table salt (sodium chloride) has been linked to conditions like heart and kidney diseases. Chloride ions are naturally occurring in water, with levels varying based on geological factors. Normally, chloride concentrations in water sources are low, but elevated levels can make water taste unpalatable for consumption.

In this study, the chloride was found in the range of 94 – 101 mg/l, which showed that all the obtained values were below the permissible limit of chloride as dictated by BIS (1000 mg/l).

Hardness

Hard water is characterized by its elevated mineral content, which distinguishes it from soft water. The predominant minerals in hard water are typically calcium (Ca^{2+}) and magnesium (Mg^{2+}) cations. Calcium typically infiltrates water sources in the form of calcium carbonate ($CaCO_3$), found in substances like limestone and chalk, or as calcium sulfate ($CaSO_4$) from various mineral deposits. Water hardness is denoted by the presence of multivalent cations. This hardness can lead to the formation of scales and reduced effectiveness of soap. In practical terms, hard water is often recognized as water that fails to produce lather with soap solutions but instead yields a white precipitate known as scum. Another definition of water hardness relates to its capacity to consume soap or the propensity to precipitate soap, representing a distinct property that inhibits soap from lathering effectively.

In this study, the hardness was found in the range of 375 – 375 mg/l, which showed that all the obtained values are below the permissible limit of hardness as dictated by BIS (600 mg/l).

Conductivity

Conductivity refers to the capacity of an aqueous solution to conduct electrical current. Several factors influence the extent to which water can conduct electricity, encompassing: (A) The concentration or abundance of ions within the solution, (B) The mobility of these ions, (C) The oxidation state (valence) of the ions, and (D) The temperature of the water. Specific conductance or conductivity measurement correlates with ionic strength, reflecting the concentration of mineral constituents present in the water and providing insights into dissolved solids. The value is contingent on the overall concentration of ionized substances, serving as an indicator of the mineral composition of distilled water quality. High conductivity suggests the presence of a significant proportion of inorganic salts. The unit of measurement for conductivity in the chemical analysis of water is micro-Siemens per centimeter (µS/cm).

In this study, the conductivity was found in the range of 220 – 280 µS/cm, which showed that all the obtained values are below the permissible limit of conductivity as dictated by BIS (3000 µS/cm).

pH

pH serves as an indicator of hydrogen ion (H_+) activity and is expressed as the reciprocal of the logarithm of this activity. The pH scale spans from 0 to 14, where values below 7 signify acidity, and values above 7 indicate alkalinity. Surface water systems typically maintain a pH range of 6.5 to 8.5, while groundwater systems generally fall within the range of 6 to 8.5. Alkalinity gauges the water's ability to resist pH alterations that might make it more acidic. Monitoring alkalinity and pH is crucial for assessing water corrosiveness. A pH level exceeding 8.5 may signal hard water, which, while not posing health risks, can lead to aesthetic issues like taste, odour and appearance. Many organisms have adapted to specific pH levels in water and may face survival challenges if pH shifts, particularly aquatic macroinvertebrates and the eggs and fry of fish. Altered pH in drinking water can affect humans in multiple ways causing skin and eye irritation, digestive problems and an increased risk of infections. Constant consumption of water with altered pH can cause irreversible damage to the heart and life-threatening diseases like cancer.

In this study, the pH was found in the range of 6.99 – 7.57, which showed that all the obtained values are below the permissible limit of pH as dictated by BIS (8.5).

Fluoride

Fluoride is a naturally occurring element found in trace amounts in soil, water, plants, and animals. When humans and other animals ingest fluoride, some of it is absorbed by body tissues, with long-term accumulation in teeth and bones. Prolonged exposure to excessive fluoride consumption throughout one's lifetime may heighten the risk of bone fractures in adults and potentially lead to bone-related discomfort and sensitivity. Fluoride compounds are the result of fluorine, an element, combining with minerals in soil or rocks. There have been concerns about potential health effects related to excessive fluoride exposure, including an elevated risk of cancer, Down's syndrome, heart disease, osteoporosis, bone fractures, acquired immunodeficiency syndrome, reduced cognitive abilities, Alzheimer's disease, allergic reactions, and various other health conditions.

In this study, the fluoride was found in the range of 0.8 – 1.2 mg/l, which showed that all the obtained values are below the permissible limit of fluoride as dictated by BIS (1.5 mg/l).

Iron

Elevated iron levels in freshwater have been a persistent concern. In household applications, water rich in iron can lead to issues such as rust buildup on plumbing fixtures, staining of laundry, and a metallic taste in drinking water. While iron itself is not a health hazard, it can give rise to taste and aesthetic problems. When iron interacts with beverages like tea and coffee, it can create a disagreeable, inky black appearance and an undesirable taste. Cooking vegetables in water with excessive iron content can result in them appearing darker and less appealing. Prolonged contact with and retention of iron in tissues may lead to conditions like conjunctivitis, choroiditis, and retinitis. In natural groundwater, iron exists in a soluble (ferrous) state, but when exposed to oxygen, it transforms into the insoluble (ferric) state, exhibiting its characteristic reddish-brown or rusty colour. Over time, this rusty sediment typically settles in the bottom of the container. However, removing iron using this settling process can be challenging and time-consuming.

In this study, the iron was found in the range of 0.8 – 1.2 mg/l, which showed that in two sites the values are above the permissible value. The permissible limit of iron is 1 mg/l (BIS standards).

Ammonia

Ammonia levels in groundwater typically range below 0.2 mg/l but can be higher, up to 3 mg/l, in specific geological formations, forested areas, or regions rich in humic substances or iron. Surface water can contain even higher ammonia levels, up to 12 mg/l. Elevated ammonia levels, above natural concentrations, can indicate fecal pollution. Chlorination of drinking water with more than 0.2 mg/L ammonia can lead to taste and odor issues along with reduced disinfection efficiency. Ammonia released from cement mortar linings in water pipes can also hinder chlorine-based disinfection. In cases of high ammonia in raw water, it can interfere with manganese-removal filters, causing oxygen depletion and off-flavors. Additionally, ammonium cations in raw water can lead to nitrite formation due to catalytic reactions or colonization by ammonium-oxidizing bacteria.

In this study, ammonia was found in the range of 0.324 – 0.33 mg/l, which showed that all the obtained values are below the permissible limit of ammonia as dictated by WHO (1.5 mg/l).

Total Dissolved Solid (TDS)

Total Dissolved Solids (TDS) in water refers to the collective concentration of dissolved inorganic and organic substances present in a given sample. TDS measurements encompass various minerals, salts, ions, metals, and organic compounds that have dissolved in water from natural sources, human activities, and environmental factors. TDS levels are typically measured in milligrams per liter (mg/L) or parts per million (ppm) and are an essential parameter in water quality analysis. Elevated TDS levels can indicate potential water quality issues, increased salinity, aesthetic concerns (such as taste and appearance), and, in extreme cases, health risks. Monitoring and interpreting TDS levels are crucial for assessing water suitability for various purposes, including drinking, agriculture, industrial processes, and environmental conservation. Proper management and treatment of water with high TDS can help ensure its safe and effective use in different applications.

In this study, the TDS was found in the range of 60 – 98 mg/l, which showed that all the obtained values are below the permissible limit of TDS as dictated by BIS (2000 mg/l).

Table 4 The values of physicochemical parameters at different locations of the Institute

S. No.	Parameters	S1	S2	S3	S4	S5
1	DO (mg/l)	0.5	0.8	0.6	1	0.4
2	BOD (mg/l)	1.8	2.6	2	3.6	1.1
3	COD (mg/l)	185	30	56	104	25
4	Alkalinity (mg/l)	560	566	565	570	580
5	Chloride (mg/l)	99	101	100	96	94
6	Hardness (mg/l)	375	375	375	375	375
7	Conductivity (µS/cm)	220	240	280	250	252
8	pH	7.075	6.999	7.432	7.568	6.99
9	Fluoride (mg/l)	1	0.8	1.1	1.2	0.9

10	Iron (mg/l)	1	0.8	1.1	1.2	0.9
11	Ammonia (mg/l)	0.324	0.326	0.325	0.33	0.327
12	TDS (mg/l)	60	98	84	82	77

Table 5 Statistical analysis of observed values of different parameters

S.No.	Parameters	Min	Max	Mean	Standard Deviation
1	DO (mg/l)	0.4	1	0.66	0.240832
2	BOD (mg/l)	1.1	3.6	2.22	0.939149
3	COD (mg/l)	25	185	80	66.52443
4	Alkalinity (mg/l)	560	580	568.2	7.496666
5	Chloride (mg/l)	94	101	98	2.915476
6	Hardness (mg/l)	375	375	375	0
7	Conductivity (µS/cm)	220	280	248.4	21.74396
8	pH	6.99	7.568	7.2128	0.268586
9	Fluoride (mg/l)	0.8	1.2	1	0.158114
10	Iron (mg/l)	0.8	1.2	1	0.158114
11	Ammonia (mg/l)	0.324	0.33	0.3264	0.002302
12	TDS (mg/l)	60	98	80.2	13.7186

Water Quality Index

Water quality index (WQI) provides an aggregated single value which represents the overall quality of water. It is calculated by testing and analyzing a variety of physicochemical parameters (as mentioned in Table 5). It is a useful tool for tracking changes in the quality of water and communicating with the public in an easy yet effective way.

The water quality index (WQI) for different sites of the institute was calculated (using the formulae discussed in section 2.2) and is shown in Table 6. Various physicochemical parameters were chosen to be tested and analyzed in accordance with the standard values dictated by recommended agencies (ICMR/BIS/WHO). We focused on these specific quality parameters for the purpose of delineating various quality classes as excellent, good, poor, very poor, and unsuitable for drinking (as per WQI). The WQI was found to be in the range of 50.33 – 73.88 for the collected water samples. This showed that the water from all five sites falls in the “good” category. Therefore, it ensures that the water from all the sites is suitable for human consumption.

Table 6 Water quality index and its quality class for each study site

S.No.	Parameters	S1	S2	S3	S4	S5
1	DO (mg/l)	0.69902	1.118432	0.838824	1.39804	0.559216
2	BOD (mg/l)	2.516472	3.634904	2.79608	5.032944	1.537844
3	COD (mg/l)	0.161648	0.026213	0.048931	0.090873	0.021844
4	Alkalinity (mg/l)	0.054368	0.054951	0.054854	0.055339	0.05631
5	Chloride (mg/l)	0.00346	0.00353	0.003495	0.003355	0.003285
6	Hardness (mg/l)	0.036407	0.036407	0.036407	0.036407	0.036407
7	Conductivity (µS/cm)	0.000854	0.000932	0.001087	0.000971	0.000979
8	pH	0.205594	0.002741	1.184222	1.557033	0.027413

9	Fluoride (mg/l)	15.53378	12.42702	17.08716	18.64053	13.9804
10	Iron (mg/l)	34.951	27.9608	38.4461	41.9412	31.4559
11	Ammonia (mg/l)	5.032944	5.064012	5.048478	5.126147	5.079545
12	TDS (mg/l)	0.000524	0.000856	0.000734	0.000716	0.000673
	WQI	59.19607	50.3308	65.54637	73.88356	52.75982
		Good	Good	Good	Good	Good

Correlation Analysis

The correlation matrix suggested that some parameters show positive correlation and some show negative correlation. In this, we have considered only those correlations in which the value of correlation coefficient (R) is > 0.5 for positive correlation and < -0.5 for negative correlation. From the above matrix table, we can see that DO and BOD show a positive correlation with a correlation coefficient of 0.99. DO shows a positive correlation with pH, iron and TDS with the value coefficients of 0.61, 0.67 and 0.53 respectively. Similarly, all the physicochemical parameters mentioned above in the table are correlated to one or more parameters showing either positive or negative correlation.

A correlation matrix is a valuable tool for developing and interpreting the Water Quality Index (WQI) in an easily understood way. It helps in identifying the most important as well as redundant water quality parameters. For example- a correlation matrix while assessing drinking water tells us that DO and pH are two parameters that are strongly related to each other. Also, both of these parameters are strongly correlated with the WQI. This information suggests that DO and pH are two important water quality parameters and they both should be included in the formula for calculating the WQI.

Likewise, turbidity and TDS are two parameters that are correlated to each other and also to the WQI. The information from the correlation matrix suggests that these are redundant parameters and only one of them is necessary to be included in the WQI formula. Overall, the correlation matrix is a valuable tool that provides an accurate and reliable assessment of the water quality.

Table 7 Correlation matrix for physiochemical parameters

Correlation Matrix	**DO**	**BOD**	**COD**	**Alkalinity**	**Chloride**	**Hardness**	**Conductivity**	**pH**	**Fluoride**	**Iron**	**Ammonia**	**TDS**
DO	1.00											
BOD	0.99	1.00										
COD	0.00	0.15	1.00									
Alkalinity	-0.17	-0.26	-0.64	1.00								
Chloride	0.18	0.18	0.10	-0.82	1.00							
Hardness	0.00	0.00	0.00	0.00	0.00	1.00						
Conductivity	0.05	0.00	-0.60	0.30	-0.03	0.00	1.00					
pH	0.61	0.66	0.16	-0.14	-0.05	0.00	0.53	1.00				
Fluoride	0.39	0.49	0.43	-0.15	-0.22	0.00	0.35	0.93	1.00			
Iron	0.39	0.49	0.43	-0.15	-0.22	0.00	0.35	0.93	1.00	1.00		
Ammonia	0.67	0.63	-0.24	0.56	-0.60	0.00	0.18	0.51	0.41	0.41	1.00	

TDS	0.53	0.40	-0.79	0.19	0.31	0.00	0.45	0.08	-0.29	-0.29	0.32	1.00

Conclusion

WQI is a useful method for assessing the quality of drinking water. This study involved the collection, preservation and analysis of water samples from five different locations of the institute. The collected samples of water were tested for various physicochemical parameters such as DO, BOD, COD, alkalinity, TDS, hardness, conductivity, pH, chloride, fluoride, iron and ammonia. All the obtained values for these parameters were found within the range of permissible standard limits as specified by the recommended agencies (ICMR/BIS/WHO), except for iron, which was evaluated against the standards of the recommended agencies for two sites of the institute. [The disrupted values for iron in the drinking water for two sites of the institute could be a result of construction in that area. Construction of new buildings can disturb the soil, releasing excessive iron from concrete and rebar into the groundwater.] However, the minor contamination of iron can easily be reversed by improving the water filtration techniques.

Furthermore, the calculation of WQI provided us with an aggregate value to judge the quality of water on a scale of 0-100. The obtained values of WQI suggested that the quality of drinking water is found to be in a “good” category for all five sites of the institute. The study's findings indicate that the water quality at different sites within the institute follows the following descending order: S2 (Ojaswini Girls Hostel) > S5 (Science Block) > S1 (Dr. APJ Abdul Kalam Boys Hostel) > S3 (Administrative Block) > S4 (New Academic Block).

References

1. S. Elsayed et al., ‘Assessment of water quality in lake qaroun using ground-based remote sensing data and artificial neural networks’, Water (Switzerland), vol. 13, no. 21, 2021, doi: 10.3390/w13213094.

2. P. Kumar, ‘Simulation of Gomti River (Lucknow City, India) future water quality under different mitigation strategies’, Heliyon, vol. 4, no. 12, 2018, doi: 10.1016/j.heliyon.2018.e01074.

3. F. García-Ávila, A. Avilés-Añazco, E. Sánchez-Cordero, L. Valdiviezo-Gonzáles, and M. D. T. Ordoñez, ‘The challenge of improving the efficiency of drinking water treatment systems in rural areas facing changes in the raw water quality’, S Afr J Chem Eng, vol. 37, 2021, doi: 10.1016/j.sajce.2021.05.010.

4. M. V. Alves Martins et al., ‘Environmental quality assessment of Bizerte Lagoon (Tunisia) using living foraminifera assemblages and a multiproxy approach’, PLoS One, vol. 10, no. 9, 2015, doi: 10.1371/journal.pone.0137250.

5. S. V. Mukate, V. M. Wagh, D. B. Panaskar, J. A. Jacobs, and A. M. Sawant, ‘Development of new integrated water quality index (IWQI) model to evaluate the drinking suitability of water’, Ecol Indic, 2019, [Online]. Available: https://api.semanticscholar.org/CorpusID:91933016

6. F. B. Britto, A. N. do Vasco, A. de O. Aguiar Netto, C. A. B. Garcia, G. F. O. Moraes, and M. G. da Silva, ‘Surface water quality assessment of the main tributaries in the lower São Francisco River, Sergipe’, RBRH, vol. 23, no. 0, p. e28, Aug. 2018, doi: 10.1590/2318-0331.231820170061.

7. S. Tyagi, B. Sharma, P. Singh, and R. Dobhal, ‘Water Quality Assessment in Terms of Water Quality Index’, American Journal of Water Resources, vol. 1, no. 3, pp. 34–38, Oct. 2020, doi: 10.12691/ajwr-1-3-3.

A. Amadi, P. Olasehinde, E. Okosun, and J. Yisa, ‘Assessment of the Water Quality Index of Otamiri and Oramiriukwa Rivers’, Physics International, vol. 1, pp. 116 – 123, Sep. 2010, doi: 10.3844/pisp.2010.116.123.

8. ICMR, Manual of standards of quality for drinking water supplies., ICMR, New Delhi, 1973.

9. BIS (Bureau of Indian Standard) (2015) Indian standard drinking water specification. second revision’. pp. 2–6.

10. BIS (Bureau of Indian Standard) (2012) Indian standard drinking water specifcation, second revision’. pp. 1–16, 2012.

11. WHO (2017) Guideline for drinking water quality, 4th edn. World Health Organization, Geneva’, 2017.

12. R. K. Horton, ‘An index number system for rating water quality, ’, Journal of Water Pollution Control Federation, vol. 37, no. 3, pp. 300–306, 1965.

13. E. S. M. W. and F. M. J. Brown, Methods for collection and analysis of water samples for dissolved minerals and gases. United States, 1970.

14. C. G. Cude, ‘OREGON WATER QUALITY INDEX A TOOL FOR EVALUATING WATER QUALITY MANAGEMENT EFFECTIVENESS1’, JAWRA Journal of the American Water Resources Association, vol. 37, no. 1, pp. 125–137, 2001, doi: https://doi.org/10.1111/j.1752-1688.2001.tb05480.x.

15. S. Tyagi, B. Sharma, and P. Singh, ‘Water Quality Assessment in Terms of Water Quality Index’, American Journal of Water Resources, vol. 1, pp. 34–38, Sep. 2013, doi: 10.12691/ajwr-1-3-3.

Issue 2: Pages 15-20.

Reconnaissance of life on Moon

Aditya Khanna and Pragyesh Kumar Agrawal

Department of Physics and Electronics
Institute for Excellence in Higher Education (IEHE) Bhopal, M.P. India

Abstract

Moon landings have been very important stepping-stones in the exploration of the universe, gaining immense amounts of knowledge and technical advancements. This review paper provides compiled data of the successes and milestones achieved by various nations in their respective lunar missions and an overview of the information and knowledge gained by them. The method used is data collection and analysis of various web archives and web sites. The discussion is about the iterations and novelty techniques developed based on the information gained from previous missions and it is the main outcome of this review paper.

Keywords: Moon Landing, Flyby, Launch, Rover, orbiter.

Introduction

Since the birth of humanity, humans have been looking at the night sky and admiring the beauty of the immaculate heavenly bodies, which gave birth to the journey of exploration of this universe. Moon exploration has been one of the most remarkable milestones in this journey.

Starting from 1958, humans have accomplished various types of missions to the Moon, which include impactors, flybys, orbiters, soft landers, rovers, sample returners and crew landers. These were sent by various space agencies such as Soviet Space Agency (USSR), National Aeronautics & Space Administration (USA), China National Space Agency (China), Japan Aerospace Exploration Agency (Japan), European Space Agency (EU), Indian Space Research Organisation (India).

The Soviet Space Agency's LUNA program achieved various milestones. The prominent are: LUNA-1 (1959) which was the first human satellite to perform a flyby over Moon, LUNA-2 (1959) was the first human satellite to impact the Moon, LUNA-3 (1959) captured the images of the far side of the Moon, LUNA-9 (1966) was the first to perform soft landing and provide pictures from the surface of the Moon, LUNA-16 (1970) was the first robotic sample return and LUNA-17 (1970) was the first rover on the Moon.

The LUNAR ORBITER[i] missions (4 & 5) (1967) performed by NASA (USA) enabled us to entirely map the lunar surface. Their APOLLO-8 (1968) mission was the first mission in which humans orbited the Moon. APOLLO-11 (1969) enabled humans to step on Moon whereas APOLLO-17 (1972) was the first mission to enable a scientist to stand on the Moon. Later, JAXA's (Japan) HITEN (1990) was the first satellite to use aerobraking and ISRO's (India) CHANDRAYAAN-1 (2008) was the first satellite to detect water locked in minerals at Moon.

Various Space Programs

A brief overview of lunar missions of various countries/agencies is as follow:

Table 1: Lunar missions launched by Soviet Space Agency (USSR) from 1959 to 1976

S.No.	NAME	LAUNCH DATE (DD-MM-YYYY)	ACHIEVEMENTS/MISSIONS/STATUS
1	LUNA-1 [FLYBY]	07-01-1959	Studied interplanetary space, provided data about radiation belt, showed absence of magnetic field around Moon, FLYBY.
2	LUNA-2 [IMPACT]	12-09-1959	Confirmed the findings of LUNA-1, IMPACTED.
3	LUNA-3 [FLYBY]	04-10-1959	Pictures of the far side of the Moon, FLYBY.
4	LUNA-4 [FLYBY]	02-04-1963	MISSED Moons by 8,336 km, unknown objective.
5	LUNA-5 [IMPACT]	09-05-1965	Originally a soft lander, retrorocket system failed, CRASHED.
6	LUNA-6 [FLYBY]	08-06-1965	Mid-course correction failed, MISSED Moon by 1,59,612 km.
7	LUNA-7 [IMPACT]	04-10-1965	Originally a soft lander, CRASHED due to premature firing of retrorocket.
8	LUNA-8 [IMPACT]	03-12-1965	Originally a soft lander, CRASHED due to late firing of retrorocket.
9	LUNA-9 [SOFT LANDER]	31-01-1966	First to achieve soft landing, provided lunar surface images.
10	LUNA-10 [ORBITER]	31-03-1966	Studied IR emissions of the Moon, performed gravitational studies.
11	LUNA-11 [ORBITER]	24-08-1966	Used X-ray & gamma-ray spectroscopy to study composition of lunar soil, studied corpuscular radiations.
12	LUNA-12 [ORBITER]	22-10-1966	Transmitted various photographs (confidential).
13	LUNA-13 [SOFT LANDER]	21-12-1966	Provided panoramic surface pictures, studied lunar surface.
14	LUNA-14 [ORBITER]	07-04-1968	Studied gravitational fields, cosmic rays, solar charged particles.
15	LUNA-15 [ORBITER]	13-07-1969	Studied circumlunar space and gravitational fields.
16	LUNA-16 [SAMPLE RETURN]	12-09-1970	First sample from far side, brought back 101 g of lunar soil.
17	LUNA-17 [ROVER]	10-11-1970	First rover 'LUNOKHOD-1' on Moon, sent 20,000 pictures, 200 panoramas, performed more than 500 soil tests.
18	LUNA-18 [ROVER]	02-09-1971	Originally a rover, CRASHED.

19	LUNA-19 [ORBITER]	28-09-1971	Studied mass concentrations, solar winds.
20	LUNA-20 [SAMPLE RETURN]	14-02-1972	Sent back 30 g of lunar soil.
21	LUNA-21 [ROVER]	08-01-1973	Second rover 'LUNOKHOD-2' on Moon, sent 80,000 pictures, 86 panoramas, planted retroreflectors for laser ranging.
22	LUNA-22 [ORBITER]	29-05-1974	Studied gravitational fields, cosmic rays.
23	LUNA-23 [SAMPLE RETURN]	28-10-1974	Originally sample return, drilling equipment DAMAGED during landing thus no samples.
24	LUNA-24 [SAMPLE RETURN]	09-08-1976	Sent back 170.1 g of lunar soil.

Overall USSR had 44 launches of which only 17 were successful.

Table 2: Missions launched by US Airforce & NASA (USA) (PIONEER MISSIONS)

S.No.	NAME	LAUNCH DATE (DD-MM-YYYY)	ACHIEVEMENTS/MISSIONS/STATUS
1	PIONEER-1	17-08-1958	First stage malfunction, FAILED.
2	PIONEER-2	11-10-1958	Set distance record, FAILED to reach Moon.
3	PIONEER-3	08-11-1958	Third stage unsuccessful, FAILED.
4	PIONEER-4	03-03-1959	Flew past Moon by 60,000 km.

Table 3: Missions launched by US Airforce & NASA (USA) (RANGER MISSIONS[ii])

S. No.	NAME	LAUNCH DATE (DD-MM-YYYY)	ACHIEVEMENTS/MISSIONS/STATUS
1	RANGER-7	28-04-1964	Shot 7000 closeup pictures of the Moon.
2	RANGER-8	17-02-1965	Helped in finding primary landing site for APOLLO missions.
3	RANGER-9	21-03-1965	Directly broadcasted images of the Moon on the television.

Table 4: Missions launched by US Airforce & NASA (USA) (SURVEYOR MISSIONS)

S.No.	NAME	LAUNCH DATE (DD-MM-YYYY)	ACHIEVEMENTS/MISSIONS/STATUS
1	SURVEYOR-1	21-05-1966	First US soft landing.

2	SURVEYOR-2	20-09-1966	IMPACTED.
3	SURVEYOR-3	17-04-1967	Visited on Moon by APOLLO-12 crew.
4	SURVEYOR-4	14-07-1967	FAILED.
5	SURVEYOR-5	1967-1968	Performed various soil tests for crew lander missions.
6	SURVEYOR-6		
7	SURVEYOR-7		

Table 5: Missions launched by US Airforce & NASA (USA) (LUNAR ORBITER MISSIONS)

S.No.	NAME	LAUNCH DATE (DD-MM-YYYY)	ACHIEVEMENTS/MISSIONS/STATUS
1	LUNAR ORBITER-1	1966-1967	Surveyed the landing site for crew lander mission.
2	LUNAR ORBITER-2		
3	LUNAR ORBITER-3		
4	LUNAR ORBITER-4	1967	Completely mapped the lunar surface.
5	LUNAR ORBITER-5		

Table 6: Missions launched by US Airforce & NASA (USA) (APOLLO MISSIONS)

S.No.	NAME	LAUNCH DATE (DD-MM-YYYY)	ACHIEVEMENTS/MISSIONS/STATUS
1	APOLLO-8	21-12-1968	First humans to orbit Moon.
2	APOLLO-10	18-05-1969	SUCCESSFUL lander test.
3	APOLLO-11	16-07-1969	First humans on Moon, brought soil and rock samples.
4	APOLLO-12,14,15,16,17	1969-1972	All crew missions were SUCCESSFUL, brought 400 kg samples.
5	APOLLO-13	11-04-1970	Mission ABORTED, crew returned safely.

Overall, USA had 47 launches of which only 24 were successful.

Table 7: Satellites launched by several other countries

S.No.	COUNTRY	NAME	LAUNCH DATE (DD-MM-YYYY)	ACHIEVEMENTS/MISSIONS/STATUS
1	JAPAN	HITEN	24-01-1980	First to implement aerobraking.
2		KAGUYA	14-09-2007	Found gravitational anomalies on near and far side of Moon.
3	EU	SMART-1	27-08-2003	First to perform test on ion drive.
4	CHINA	CHANG'E-1	24-10-2007	First Chinese satellite to Moon.

5		CHANG'E-2	01-10-2010	SUCCESSFUL.
6		CHANG'E-3	06-12-2013	Delivered Chinese rover 'YUTU-1'.
7		CHANG'E-4	07-12-2018	Delivered Chinese rover 'YUTU-2'.
8		CHANG'E-5	23-11-2020	First Chinese sample return mission.
9	INDIA	CHANDRAYAAN-1	22-10-2008	First Indian lunar mission, DISCOVERED water locked in minerals, IMPACTED.
10		CHANDRAYAAN-2	22-07-2019	SUCCESSFUL orbiter, lander CRASHED.
11		CHANDRAYAAN-3	23-08-2023	First Indian soft landing, delivered rover 'PRAGYAAN'.
12	RUSSIA	LUNA-25	10-08-2023	FAILED.

Apart from all these countries various other countries have also attempted lunar missions such as Israel, Luxembourg, South Korea, Italy, UAE. Continuing this race to Moon there are a plethora of mission which would be executed by the end of this decade. These missions include flybys, orbiters, rovers, sample returners and crew lander missions.

Conclusions

The main question that arises is, why do we need to explore the Moon. The answer is it is because of the advantages Moon provides when it comes to deep space exploration as it can be used as a launching site since it has less gravity than Earth (1/6th), also the findings of CHANDRAYAAN-1 showed the existence of water locked in minerals, since water can be separated into Hydrogen and Oxygen which in turn can be used as a fuel.

More than 60 years of Moon exploration have taught humans' various things such as,

i) Trajectories – Earlier USA and USSR used direct shot method wherein they directly shot the satellite towards the Moon. This method was indeed fast but vastly inefficient. Later, they adapted two stage method, in which they first shot the satellite into Earth's orbit and from there they shot into Moon's orbit. It took more time but this method was more efficient than the former. Currently, India uses the slingshot method, in which we accelerate the satellite in elliptical orbit till it attains enough speed to reach Moon's orbit. It is the slowest but the most efficient method as it consumes the least amount of fuel.

ii) Autonomous Softwares – Earlier, every operation and maneuver performed by the satellite was precalculated and there were close to none onboard corrections that could be conducted. Now the softwares are capable enough to determine the perfect landing spot as well as provide the necessary commands to maneuver the satellite.

iii) Hardware Development – Not only the propulsion systems but also the telemetry, photography and navigation systems have been immensely researched and developed.

iv) Scientific Discoveries – From the discovery of absence of magnetic field around the Moon to the presence of water on the Moon, we humans have discovered a variety of things and more are yet to be discovered.

References

1. Williams, D. R. (2005). *Soviet Lunar Missions*. Retrieved from Internet Archieve WayBack Machine: http://nssdc.gsfc.nasa.gov/planetary/lunar/lunarussr.html (date of retrieve 08/09/2023)

2. Williams, D. R. (2006, September 16). *Lunar Orbiter (1966 - 1967)*. Retrieved from Internet Archieve Wayback Machine : http://nssdc.gsfc.nasa.gov/planetary/lunar/lunarorb.html (date of retrieve 08/09/2023)

3. Williams, D. R. (2007, July 24). *The Apollo Program (1963 - 1972)*. Retrieved from Internet Archive WayBack Machine: http://nssdc.gsfc.nasa.gov/planetary/lunar/apollo.html (date of retrieve 08/09/2023)

4. *Hiten*. (n.d.). Retrieved from Institue of Space and Aeronautical Sciences : https://www.isas.jaxa.jp/en/missions/spacecraft/past/hiten.html (date of retrieve 08/09/2023)

5. *Chandrayaan-1*. (n.d.). Retrieved from Indian Space research Organisation, Department of Space https://www.isro.gov.in/ISRO_EN/Chandrayaan_1.html (date of retrieve 08/09/2023)

6. Jones, A., Barry, C., & Vogel, T. (n.d.). *Moon Missions*. Retrieved from Nasa Science Earth's Moon: https://moon.nasa.gov/exploration/moon-missions/ (date of retrieve 08/09/2023)

7. *Pioneer*. (n.d.). Retrieved from Internet Archive WayBack Machines: http://leonardo.jpl.nasa.gov/msl/Programs/pioneer.html (date of retrieve 08/09/2023)

8. *The Ranger Program*. (2000, September 18). Retrieved from Internet Archive WayBAck Machine: http://cass.jsc.nasa.gov/expmoon/ranger/ranger.html (date of retrieve 08/09/2023

9. Williams, D. R. (2006, October 05). *Surveyor (1966 - 1968)*. Retrieved from Internet Archive WayBack Machine: http://nssdc.gsfc.nasa.gov/planetary/lunar/surveyor.html (date of retrieve 08/09/2023)

10. *List of Moon Missions* . (n.d.). Retrieved from Wikipedia: https://en.m.wikipedia.org/wiki/List_of_missions_to_the_Moon (date of retrieve 11/09/2023)

Issue 2: Pages 21-26.

Air Pollution effect on *Taberneamontana divaricata*: A comparative Study

Dr. Jyoti Saxena and Ankita Kulshreshtha

Department of Chemistry,
Institute for Excellence in Higher Education (IEHE) Bhopal, M.P. India

Abstract

A comparative study was conducted to assess the impact of air pollution on Taberneamontana divaricata plants, utilizing the Air Pollution Tolerance Index (APTI). Standard methods were employed to perform phytochemical tests, including pH, relative water content, total chlorophyll content, and total ascorbic acid, on the plant's leaves. The APTI was subsequently calculated for two sets of leaf samples: one obtained from a highly polluted roadside location and another from a nearby unpolluted park. The results of the study demonstrated that the leaves from the unpolluted park exhibited a higher APTI, indicating a moderate tolerance to air pollution, in contrast to the leaves from the polluted roadside, which displayed a lower tolerance, signifying sensitivity to pollution. These findings further underscore the importance of phytochemical composition, including factors such as pH, relative water content, total chlorophyll content, and total ascorbic acid, in determining a plant's tolerance to environmental stressors.

Keywords: *T. divaricata, Leaf, Total Chlorophyll Content, Total Ascorbic Acid content, Air Pollution Tolerance Index*

Introduction

Air pollution is a widespread issue that has far-reaching effects on various aspects of life, stemming from both natural and human-induced factors, which contribute to ecosystem degradation and pose risks to human health (Dwijendra *et al.,* 2023). Plants play a crucial role in restoring air quality equilibrium through their absorption and metabolic processes (Wei *et al.,* 2021). Particularly, roadside plants are efficient interceptors of airborne pollutants, significantly contributing to the assimilation and accumulation of harmful substances. Several previous studies have examined the adverse impacts of urban air pollution on the leaf structure of plants (Carreras *et al.,* 1996; Hirano *et al.,* 1995; Kulshreshtha *et al.,* 1994).

Air pollutants encompass substances like sulfur, nitrogen oxides, carbon monoxide, soot particles, as well as trace amounts of toxic metals, organic compounds, and radioactive isotopes. These pollutants can directly affect plants through their leaves or indirectly through soil acidification. Most plants undergo physiological changes before displaying visible leaf damage (Dohmen *et al.,* 1990). Therefore, researchers have focused on various parameters to study the adverse effects of air pollution, including chlorophyll content (Prasad and Inamdar., 1990; Rajkput and Agarwal., 2005; Petkovsek *et al.,* 2008; Chauhan and Kumar., 2008; Chauhan and Joshi., 2008 and 2010), relative moisture content (Falla *et al.,* 2000; Joshi and Chauhan., 2008), ascorbic acid content (Hoque *et al.,* 2007), and the Air Pollution Tolerance Index (APTI) of select plants (Karthiyayini *et al.,* 2005; Dwivedi and Tripathi., 2007). APTI helps identify the tolerance levels of different plant species (Singh and Rao., 1983; Singh *et al.,* 1991; Yan Ju and Hui., 2008; Agbaire and Esief., 2009).

One cost-effective and appealing approach to improving air quality and controlling air pollution is the use of plants to remove toxins, known as phytoremediation (Gajghate and Hassan., 1999). To understand the response of plants to air pollution at physiological and biochemical levels, researchers use the Air Pollution Tolerance Index (APTI), which is calculated using four biochemical parameters: pH, relative water content, total chlorophyll content, and total ascorbic acid content (Singh and Rao., 1983). Species with higher APTI values exhibit greater tolerance to air pollution than those with lower APTI values. Species with lower APTI values can serve as bio-indicators of pollution.

Tabernaemontana divaricata, often referred to as "crepe jasmine" or "Chandani," serves as a key repository of phytochemical compounds, demonstrating its significance in various applications, as substantiated by previous research findings. Hence, the present study was centered on assessing the Air Pollution Tolerance Index (APTI) of *T. divaricata* leaves. This investigation underscores the fact that the plant's ability to withstand air pollution is linked to the phytochemical composition in its leaves, which may be adversely affected by environmental pollution.

Methodology

Sampling

For this study, leaves of *T. divaricata*, which were authenticated by a Taxonomist from Safia College of Science in Bhopal, Madhya Pradesh, India. One set of samples was obtained from a location near a polluted roadside, while the other set was collected from a nearby unpolluted park in Bhopal city, Madhya Pradesh, India.

pH of Leaf Extracts

Two fresh leaf samples were combined with 10 ml of distilled water and the resulting leaf extract was filtered. The pH of the leaf extract was measured after calibrating the pH meter using a pH-4 buffer solution (Agbaire and Esief., 2009).

Relative Water Content (RWC)

The initial fresh weight of the leaves was recorded by weighing them. To obtain the dry weight, the leaves were dried in an oven at 70°C overnight, and the dry weight was subsequently measured. For the turgid weight, the leaves were soaked in water overnight, dried, and then weighed (Singh., 1997) and calculated with the formula as below:

Relative Water Content (%) = FW - DW / TW – DW x 100

Where, FW – Fresh weight of leaf, DW – Dry weight of leaf, TW – Turgid weight of leaf.

Total Chlorophyll Content

Fresh leaves from both plants were collected for the analysis of total chlorophyll content. For total chlorophyll determination, 0.5 g of fresh leaf material was ground and diluted in 10 ml of distilled water. A subsample of 2.5 ml was mixed with 10 ml of acetone and allowed to stand for 15 minutes. It was then filtered and centrifuged at 2500 rpm for 3 minutes. The optical density of the supernatant was measured at 645 nm and 663 nm using a digital spectrophotometer (Aminot and Rey., 2000). The concentrations of chlorophyll a and chlorophyll b (mg/g fresh leaf) were calculated using the following formula:

Total Chlorophyll: 20.2(A645) + 8.02(A663)

Chlorophyll a: 12.7(A663) – 2.69(A645)
Chlorophyll b: 22.9(A645) – 4.68(A663)

Total Ascorbic Acid Content

A standard calibration curve for ascorbic acid was established by plotting concentrations against the absorbance of ascorbic acid standard solutions. This was achieved by taking 10 ml of each standard solution (ranging from 5 to 25 µg/ml) and adding 1 ml of a $KMnO_4$ solution (100 µg/ml). The solutions were left to stand for 5 minutes, and the absorbance of these standard solutions was read at 530 nm against a blank. Following calibration, 10 ml of each extract sample (1 mg/ml) was placed in a test tube, and 1 ml of the $KMnO_4$ solution (100 µg/ml) was added. After standing for 5 minutes, the absorbance of these solutions was read at 530 nm against a blank using a UV/Visible spectrophotometer (Elgailani *et al.,* 2017).

Air Pollution Tolerance Index (APTI)

The determination of APTI (Air Pollution Tolerance Index) was carried out using the method outlined by Singh and Rao in 1983. The APTI was calculated using the following formula:

APTI = A (T+P) +R / 10

Where, A = Total ascorbic acid content (mg/g), T = Total chlorophyll (mg/g), P = pH of leaf extract, R = Relative water content of leaf.

Plant species are classified based on their APTI (Air Pollution Tolerance Index) values. Those with APTI values between 30 and 100 are considered tolerant to air pollution, while those with values between 17 and 29 are moderately tolerant. Sensitive plant species typically have APTI values ranging from 1 to 16, and those with APTI values less than 1 are considered highly sensitive to air pollution.

Result and Discussion

Observations of pH, relative water content, total chlorophyll content and total ascorbic acid for determination of APTI of both studied are depicted in table 1.

Table 1: Results of comparative study of APTI

Sample Name	pH of Leaf Extract	Relative Moisture (%)	Total Chlorophyll Content (mg/100 mg)	Total Ascorbic Acid Content (mg/100 mg)	APTI
Leaf 1	6.8	78.41	10.10 (Chlorophyll a- 8.19 and Chlorophyll b- 1.91)	5.651	17.39
Leaf 2	6.5	70.82	4.486 (Chlorophyll a- 4.194 and Chlorophyll b- 0.295)	0.114	07.19
Where, Leaf 1 = Leaf Collected From Unpolluted park, Leaf 2= Leaf Collected From Polluted Road Side					

The pH values were determined to be 6.8 for leaf extracts from an unpolluted park and 6.5 for leaf extracts from a polluted roadside. The relative water content was measured at 78.41% for leaves from the unpolluted park and 70.82% for leaves from the polluted roadside.

In terms of total chlorophyll content, the results showed 10.10 mg/100 mg in leaf extracts from the unpolluted park and 4.486 mg/100 mg in leaf extracts from the polluted roadside. The total ascorbic acid content was found to be 5.651 mg/100 mg for leaves from the unpolluted park and 0.114 mg/100 mg for leaves from the polluted roadside.

In an assessment of the Air Pollution Tolerance Index (APTI), a leaf sample obtained from an unpolluted park displayed a moderate level of tolerance with a value of 17.39. Conversely, a leaf sample collected from a polluted roadside exhibited a lower APTI value of 7.19, signifying the sensitivity of the plant species to air pollution.

Conclusion

In this study, comparative study of air pollution tolerance index (APTI) was calculated for two leaf samples, one sample was obtained from a heavily polluted roadside, while the other was collected from a nearby pristine park. The results of the study demonstrated that the leaves from the unpolluted park exhibited a higher APTI, indicating a moderate tolerance to air pollution, in contrast to the leaves from the polluted roadside, which displayed a lower tolerance, signifying sensitivity to pollution. These findings further underscore the importance of phytochemical composition, including factors such as pH, relative water content, total chlorophyll content, and total ascorbic acid, in determining a plant's tolerance to environmental stressors.

Acknowledgement

We acknowledge to the Director, Institute for Excellence in Higher Education, Bhopal, Madhya Pradesh, India, for encouragement of research work and kind permission to publish this paper. Authors also acknowledge the help received from everyone in laboratory for this study work.

References

1. Agbaire PO and Esief Arienrhe E. Air pollution tolerance indices (APTI) of some plants around Otorogun Gas plant in Delta state, Nigeria. Journal of Applied Science and Environmental Management. 2009, 13(1): 11-14.

2. Aminot A and Rey F. Chlorophyll a: Determination by spectroscopic methods. ICES Techniqnes in Marine Environmental Sciences. 2001, 30: 17.

3. Carreras HA, Canas MS and Pagnate ML. Differences in responses to urban air pollutants by *Ligustrumlucidum Ait*. F. tricolor (Rehd.). Environment Pollution. 1996, 2: 211-218.

4. Chauhan A and Kumar S. Impact of dust pollution on photosynthetic pigments of some selected trees grown at nearby of stone-crushers. Environment Conservation Journal. 2008, 9(3): 11 – 13.

5. Chauhan A and Joshi PC. Effect of ambient air pollutants on wheat and mustard crops growing in the vicinity of urban and industrial areas. New York Science journal. 2010, 3(2):52-58.

6. Dwijendra ANK, Mohammadi MJ, Aravindhan S, Turki Jalil A, Taherian M, Heri Iswanto A, Ajam Ekrami H, Alborzi M and Mousavion K. Investigating the Effects of Air Pollution on Plant Species Resistance in Urban Areas. Health Scope. 2023, 12(1):129786.

7. Dwivedi A K and Tripathi B D. Pollution tolerance and distribution of plants in surrounding area of coal-fired industries. Journal of Environmental Biology. 2007, 28(2):257-263.

8. Dohmen G P. Loppers A and Langebartels C. Biochemical response of Norway Spruce (*Picea Abies (L) Karst*) Toward 14 – Month exposure to ozone and acid mist effect on amino acid, Glutathione and Polyamine Titers. Environmental Pollution. 1990, 64: 375-383.

9. Elgailani I E H, Gad-Elkareem M A M, Noh A A E, Adam O E A, Alghamdi A M A. Comparison of Two Methods for The Determination of Vitamin C (Ascorbic Acid) in Some Fruits, American Journal of Chemistry. 2017, 2 (1): 1-7.

10. Falla J, Gilly P L, Honryon M, Morlot D and Ferard JF. Biological air quality monitoring – A review, Environment Monitoring and Assessment. 2000, 64(3): 627-644.

11. Gajghate DG and Hassan MZ. Ambient lead levels in urban areas. Bulletin of Environmental Contamination and Toxicology.1999, 62: 403-408.

12. Hirano T, Kiyota M and Aiga I. Physical effects of dust on leaf physiology of cucumber and kidney bean plants. Environmental Pollution.1995, 89: 255-261.

13. Hoque M A. Banu MNA and Oluma E. Exogenous proline and glycinebetaine increase NaCl-induced Ascorbate glythione cycle enzyme activities and proline improves salt tolerance more that glycinebetaine in tobacco bright yellow – 2 suspension cultural cells. Journal of Plant Physiology. 2007, 164: 1457-1468.

14. Joshi P C and Chauhan A. Performance of locally grown rice plants *(Oryza sativa L.)* exposed to air pollutants in a rapidly growing industrial area of district Haridwar, Uttarakhand, India, Life Science Journal. 2008, 5(3): 41-45.

15. Karthiyayini R, Ponnammal N R and Joseph R. Air pollution tolerance index of certain plants of Coimbatore Ooty highways, near ITI area, Coimbatore, T.N. Pollution Resource. 2005, 24(2): 363-365.

16. Kulshreshtha K, Farooqui A, Srivastava K, Singh SN, Ahmad KJ and Behl HM. Effect of diesel pollution on cuticular and epidermal features of *Lantana camara Linn.* and *Syzygiumcumini Linn*. Journal of Environment Science and Health. 1994, 29: 301-308.

17. Maclachlan A C and Yentsch C S. Plastid structure, composition of a chlorophyll mutant of barley, Canada journal of Botany.1963, 41: 1053 – 1062.

18. Petkovsek S A S, Batic F and Lansik C R. Norway Spruce needles as bioindicator of air pollution in the area of influence of the Sostant Thermal Power Plant, Slovenia. Environmental Pollution. 2008, 151: 287-291.

19. Prasad MSV and Inamdar JA. Effect of cement kiln dust pollution on black gram (*Vigna mungo (L.) Hepper*). Proceedings of the Indian National Science Academy. 1990, 100(6): 435-443.

20. Rajput M and Agarwal M. Biomonitoring of air pollution in a seasonally dry tropical suburban area using wheat transplants. Environmental Monitoring and Assessment. 2005, 101: 39– 53.

21. Sharma B, Sharma S, Bhardwaj SK, Kaur L and Sharma A. Evaluation of Air Pollution Tolerance Index (APTI) as a tool to monitor pollution and green belt development: A review. Journal of Applied and Natural Science, 2017; 9 (3): 1637 -1643.

22. Singh A. Practical Plant Physiology.1977, Kalyani Publishers, New Delhi.

23. Singh S K and Rao D N. Evaluation of the plants for their tolerance to air pollution. Proceedings of Symposium on air pollution control held at ITI, Delhi. 1983, 218 – 224.

24. Singh S K, Rao D N, Agarwal M, Panday J and Narayan D. Air pollution tolerance index of plants, Journal of Environmental Management, 1991, 32: 45 – 55.

25. Yan – Ju L, and Hui D. Variation in air pollution tolerance index of plant near a steel factory; implications for landscape – plant species selection for industrial areas, Environmental and Development. 2008, 1(4): 24 – 30.

26. Wei Z, Le QV, Peng W, Yang Y, Yang H, Gu H, Lam SS and Sonne C. A review on phytoremediation of contaminants in air, water and soil. Journal of Hazardous Material. 2021, 403: 123658.

IEHE The Quest | Volume II | 2023.

Issue 2: Pages 27-35.

Applicability and Constraints of Implementing Artificial Intelligence in Biotechnology and Healthcare

Hari Krishna Garg, Aamna Khan, Precious Ganveer, Shyli Sen, and Swayam Malviya

Department of Biotechnology
Institute for Excellence in Higher Education (IEHE), Bhopal 462016 M.P. India

Abstract

The present project investigates the feasibility and limitations of implementing Artificial Intelligence (AI) in healthcare and biotechnology through a global analysis of use cases. The sudy aims to assess the practicality and viability of implementing AI solutions in these fields, examining their real-world impact on diagnostics, treatment, drug discovery, and patient care.

Key objectives involve identifying successful use cases demonstrating AI's positive contributions and elucidating potential barriers and ethical considerations. Utilizing a mixed-methods approach, the study employs an extensive survey and interview-based research methodology to gather insights from diverse stakeholders. The survey quantifies current adoption rates, perceived benefits, and challenges associated with AI integration. The majority of the population agrees that regulations are necessary to ensure responsible AI use. Interviews with experts further explore perspectives, highlighting AI's potential as a valuable tool for education and social institutions, generating skilled jobs, and enhancing social life. However, challenges such as the destruction of manual labor, the digital divide, and concerns about human attention spans and IQs are also noted.

This initiative underscores moral, ethical, and legal concerns while examining the potential of AI and Machine Learning (ML) in genomics, biotechnology, and healthcare. Recommendations include increasing public awareness, establishing organizations, and prioritizing user privacy. The initiative aims to ensure that research is conducted ethically and practically, understanding AI applications, gathering insights, and analyzing potential difficulties.

Introduction

Artificial Intelligence (AI) is a rapidly expanding field within computer science that strives to develop machines capable of executing cognitive tasks such as creativity, problem-solving, decision-making, and reasoning. Its foundations lie in a multidisciplinary approach, encompassing economics, probability, psychology, linguistics, philosophy, neuroscience, mathematics, search, and mathematical optimization. The origins of AI trace back to ancient philosophical inquiries into the potential of artificial beings, with significant advancements occurring since the 1700s, enabling the automation and control of human thought [Garg, 2021].

Categorically, AI can be classified into three types based on capabilities: General Artificial Intelligence (GAI), Super AI, and Weak/Narrow AI. GAI is proficient in performing any intellectual task as effectively as a human, while narrow AI is more prevalent and easily accessible. Super AI, boasting superior cognitive abilities, surpasses human performance in various tasks.

AI architectures comprise Multilayer Perceptron (MLP), Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), and Generative Adversarial Networks (GAN). MLP, the foundational neural network design, consists of input, hidden, and output layers. CNN addresses computer vision challenges like image identification and classification. RNN excels in handling sequential data such as time series and natural language processing, while GAN produces data mirroring training data properties, utilizing a discriminator to verify input image authenticity.

This study aims to analyze the applications of AI and Machine Learning (ML) in biotechnology, healthcare, and genomics. It seeks to explore emerging technologies with substantial potential for human advancement, investigate regulatory and ethical considerations, and examine potential global use-cases and software integration in these fields. Additionally, the study probes into the increasing utilization of AI and ML across diverse sectors, including agriculture, medical biology, industrial biotechnology, healthcare, genomics, and bioinformatics.

In agriculture, AI and ML play a pivotal role in cultivating new plant traits through conventional methods such as plant rearing, micropropagation, and tissue culture. In medical biology, these technologies contribute to drug and antibiotic development, focusing on DNA and genetic manipulation. Industrial biotechnology leverages IoT technologies for enhanced data management and reduced specimen handling. In healthcare, AI is integral to precision medicine, while genomics benefits from AI insights into gene functions and disease risks. Bioinformatics applications encompass protein-protein interaction, biological sequencing, and functional structure analysis, aiding in drug discovery and complex systems. Key applications in bioinformatics include gene editing experiments, protein structure identification [Jumper et al., 2021], drug repurposing, and analysis of protein-protein interactions.

Methodology

This research investigates the global applications of AI and ML in healthcare, genomics, and biotechnology, focusing on feasibility and limitations. Utilizing a mixed-methods approach, both quantitative and qualitative methods were employed. An online survey covered AI & ML usage in daily life, biotechnology, genomics, and healthcare. Additionally, semi-structured interviews with 10 participants from diverse fields provided qualitative insights. RStudio software was used for data analysis, incorporating insights from interviews.

Experts from various domains were initially queried about the prevalence of AI in the current scenario. Subsequently, they shared insights on how AI is revolutionizing their respective domains. Several key themes emerged regarding challenges, potential solutions, and the future perspectives of AI and ML use.

AI's impact extends beyond healthcare and biotechnology, offering value in education and social institutions by creating skilled jobs and enhancing social life. However, challenges such as the erosion of manual labor, the digital divide, and potential effects on attention spans and IQs exist. Furthermore, inadequate digital literacy in rural areas may lead to an inferiority complex and a lack of basic knowledge, potentially resulting in increased disputes, decreased morals, and societal collapse.

From a psychological standpoint, AI can provide new insights into human behavior through monitoring social media, credit card spending, GPS data, and smartphone metrics. Challenges include potential compromises in human relationships, emotional impacts, and risks to physical and mental health. Privacy invasion and increased crime rates are additional concerns, and virtual interactions may contribute to feelings of loneliness, anxiety, and depression.

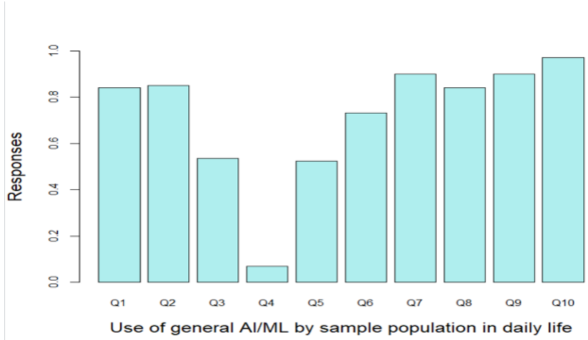
Ethical considerations were prioritized, ensuring confidentiality and anonymity through verification of the interviewees' official IDs. It is crucial to acknowledge limitations, such as sample size and potential survey response bias, when interpreting results for data validity.

Results

This section presents the analysis of the conducted survey using RStudio. The results of the survey, based on a sample size of 101 individuals, primarily composed of students, are interpreted.

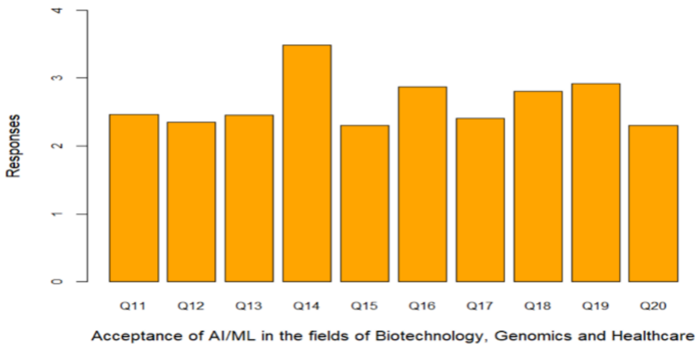
Section-1: General uses of AI/ML in daily life

This section explores the widespread applications of AI/ML in everyday life, emphasizing the familiarity of the sample population with these technologies. According to the graph, a majority of individuals are aware of AI/ML in their daily activities, with navigation apps emerging as the most commonly used application. Conversely, the sample population exhibits lower awareness levels regarding AI/ML-based recommendation systems, as well as dating apps designed for suggesting potential matches.



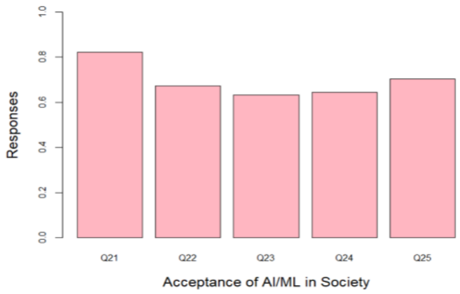
Section-2: Use of AI/ML in the fields of Biotechnology, Genomics and Healthcare.

The present section explores the application of AI/ML in biotechnology, genomics, and healthcare, posing 10 questions on related applications and ethical considerations. A significant portion of the surveyed population supports the need for regulations to ensure responsible AI/ML utilization. However, there is dissent regarding the creation of synthetic models and data mimicking natural phenomena using AI/ML. Similarly, there is disagreement concerning the development of genetically modified organisms capable of thriving in harsh conditions for exploration purposes. Overall, the majority of the population does not share consensus on these particular concerns.



Section-3: Ethical and Psychological implications of AI/ML on society

The section posed five questions with Acceptable/Unacceptable options, addressing scenarios arising from AI/ML prevalence. If they align with the sample population's ethics and morals, the option was "Acceptable." Inferences drawn include generally acceptance of AI/ML in society, acceptance of challenges to human uniqueness in creative fields, and concern for job displacement due to AI/ML advancements.



Applications and Global Use Cases

1. Medical imaging

AI has significantly advanced medical imaging and diagnostics, revolutionizing the way medical professionals diagnose and treat various conditions. Applications of AI integration include image analysis and interpretation, tumor detection, disease classification, personalized treatment planning, real-time monitoring, data management and analysis, and radiomics. Microsoft Corporation, a multinational entity, has collaborated with the Department of Oncology at Addenbrooke's Hospital for over a decade to pioneer technologies for radiotherapy. Their project, OSAIRIS, utilizes open-source software to streamline the process from radiotherapy referral to treatment, reducing the time involved. Meanwhile, Thorina, founded by Eva van Rikxoort, focuses on using AI for personalized treatments in lung diseases. Both companies prioritize integrating AI into their services, emphasizing advanced lung image analysis and providing high-precision AI-based services for pharmaceutical companies. Through AI implementation in medical imaging, entities like Microsoft and Thorina enhance diagnostic accuracy, identify tumors, and elevate patient care.

Microsoft's Project InnerEye Open-Source Software (OSS) serves as a tool for medical imaging and quick contouring for radiotherapy, easing the workload of CT scans for cancer patients [Microsoft, 2023]. This software employs Convolutional Neural Networks (CNN) for automatic segmentation of medical images, developed through Microsoft Azure Machine Learning (ML) on 20 NVIDIA Tesla V100 GPUs. The model significantly accelerates end-to-end image segmentation and annotation in radiotherapy, achieving almost 13 times faster results with high accuracy. The software is freely available under an MIT open-source license, ensuring accessibility for the global medical imaging community.

Thirona's CAD4COVID utilizes AI with deep learning capabilities to predict COVID-19 and pneumonia through chest CT quantification. These technologies aid in identifying lobular regions affected by COVID-19 or pneumonia, minimizing the reliance on manual CT scans..

2. Robotic Surgery

AI and machine learning have significantly enhanced robotic surgery by improving precision, safety, and effectiveness. Key applications encompass patient-specific modeling, virtual simulation, assisted and autonomous surgery, image analysis, recognition, and learning from surgical data. AI enables the creation of patient-specific 3D models, real-time assistance for surgeons, and the autonomy of robots in performing specific steps under the surgeon's supervision. Image recognition aids in identifying target structures and vessels, while learning from surgical data facilitates outcome prediction and the refinement of surgical techniques. Safety enhancements include error detection and risk mitigation.

The Mayo Clinic, established in the late 19th century, has integrated over 15,000 Apple mobile devices into patient care and developed Synthesis Mobile, a platform integrating various healthcare systems. Additionally, the clinic has formed strategic partnerships with Google and NTT Venture Capital for a biomedical software startup called Inference. Presently, the Mayo Clinic is offering two da Vinci SP robot-assisted surgical systems to patients.

The da Vinci Surgical System, consisting of advanced instruments for minimally invasive surgeries, translates the surgeon's hand movements in real time via a console [Intuitive, 2023]. It provides high-definition 3D views of the surgical area and comprises a surgeon console, patient's cart, and vision cart. Evolving from da Vinci OS1 in 2000 to da Vinci OS4, which powers fourth-generation systems, the system aids in intraoperative decisions, offers insights, supports SimNow simulation technology, and integrates data communication among components.

3. Oncology research

AI and machine learning (ML) algorithms play a pivotal role in cancer research, offering capabilities such as early cancer detection, personalized treatment planning, accelerated drug discovery, prognosis prediction, and facilitation of precision medicine. Established in 1998, Google has made substantial investments in AI research and development, showcasing products like Google Assistant and seamlessly integrating AI across its services. The company is a key player in the competitive cloud computing industry, challenging giants like Amazon Web Services and Microsoft Azure.

Pioneering the field of cognitive computing, IBM and Pfizer stand out with Watson, the first commercially available cognitive computing capability. Pfizer has effectively employed Watson for Drug Discovery, customizing this cloud-based cognitive tool to enhance the identification of new drug targets and the formulation of patient selection strategies in immuno-oncology [Pfizer, 2016].

Deep Mind, a division of Alphabet, Inc. (Google's parent company), specializes in developing general-purpose artificial intelligence (AGI) technology. It utilizes raw pixel data as input, learning from experience, and integrating both physical and biological knowledge about protein structure.

Google's Deep Learning System (DLS) employs multiple Convolutional Neural Network (CNN) modules for the survival prediction of various cancer types. The system optimizes layer sizes and the number of layers using random grid-search techniques.

IBM's Watson AI, created by DeepQA, collaborates with Pfizer in immune-oncology research and drug delivery. The cloud-based software, IBM Watson Health for Drug Delivery, aids in the discovery of new drug targets and alternative indications. Leveraging cognitive computing, it dissects questions into keywords to identify statistically related phrases within the database, providing sensible and relevant results.

4. Next generation sequencing

AI and machine learning (ML) play a crucial role in next-generation sequencing (NGS) applications, spanning read alignment, variant calling, quality control, transcriptomics analysis, and clinical interpretation. Key players in this domain, such as Illumina and Nvidia, concentrate on advancing DNA sequencing and array-based technologies for genotyping and gene expression, contributing significantly to genomics and personalized medicine.

Illumina's TruSight Software Suite, developed by the company [Illumina, 2023], integrates AI and ML tools for variant analysis and interpretation in rare disease research. Components like SpliceAI, PrimeAI, and Emedgene utilize deep Residual Neural Network architecture (ResNET) and deep learning neural networks. On the other hand, Nvidia's Clara Parabricks, designed for secondary genomic analysis, delivers rapid, cost-effective results for both DNA and RNA sequences.

Within Illumina's TruSight Software Suite, SpliceAI, PrimeAI, and Emedgene operate on deep learning neural networks, streamlining and automating the variant classification process. Similarly, Nvidia's Clara Parabricks serves as a comprehensive software suite for secondary genomic analysis, ensuring swift and economical outcomes for extensive and intricate sequencing datasets [Nvidia, 2023]. Both companies remain committed to advancing next-generation sequencing and ML technologies, aiming to enhance accuracy, efficiency, and overall quality in genomic research.

5. Genetic Engineering

AI and ML play a crucial role in genetic engineering, encompassing various applications such as gene editing, gene expression, synthetic biology, metabolic engineering, and protein engineering {Garg, 2022]. Companies like Zymergen leverage the integration of genetic engineering and ML to develop programmed microorganisms. Zymergen utilizes an in-house Python-based system named Helix to translate human-interpretable ideas for gene modification into a low-level DNA language. This modified genetic information is then introduced into microorganisms through the insertion of a physical DNA loop between two points in the DNA sequence [Zymergen, 2023].

To assess the performance of these modified microorganisms, small-scale, high-throughput experiments are conducted. Python is employed for data preprocessing, retrieval, model updating, and recommendation generation. Experimental outcomes and biological features are used to train ML models, which, in turn, provide recommendations for designing strains. Automated robots support parallelized small-scale experiments, enhancing efficiency.

Biological feature extraction focuses on metabolism, recognized as the quickest pathway for enhancing desired chemical production. Metabolic networks are employed to derive traditional graph metrics for ML application. Additionally, Flux Balance Analysis (FBA) is utilized to interpret graphs in scientific content. This integrated approach optimizes the genetic engineering process, combining AI and ML for efficient and effective results.

6. Clinical Data Managment

AI and ML are essential in clinical data management, offering a holistic perspective on patient health, data cleansing, predictive analytics, clinical decision support, and patient monitoring.

Established in 1999, Medidata Solutions, Inc. is a technology firm specializing in cloud-based solutions for clinical research in the life sciences sector. Their software platform, Rave, integrates clinical data management, pharmacovigilance, and clinical research, facilitating seamless information flow and addressing data quantity and integrity issues. Rave encompasses various types tailored to meet diverse pharmaceutical field requirements, such as Safety Gateway, EDC, Imaging, Targeted SDV, Coder, Safety Analytics, and RTSM. These tools contribute to pharmacovigilance, safety management, medical image management, risk-based monitoring, medical coding, safety analytics, and supply management. Medidata's continuous innovation has revolutionized clinical trials by boosting efficiency, data quality, and collaboration among researchers, sponsors, and regulatory agencies.

Feasibility

Artificial Intelligence (AI) and Machine Learning (ML) offer significant potential in healthcare and biotechnology, leveraging data-driven insights from diverse sources for precise predictions and informed decision-making. These technologies accelerate drug discovery by predicting candidates, simulating molecular interactions, and optimizing drug properties. Analyzing individual genetic and molecular data enables personalized medicine.

AI and ML play a pivotal role in early disease detection, accurate diagnosis, and prognosis through the analysis of medical images, genomic data, and clinical records. They identify biomarkers indicating disease presence or progression. In genomics, these technologies excel at analyzing gene interactions, predicting functions, and discovering mutations linked to diseases.

Protein structure prediction is a domain where AI and ML excel, forecasting 3D structures to advance drug design and disease research. In agriculture, they optimize crop yield, detect diseases, and improve breeding for sustainable and efficient food production.

In synthetic biology and bioengineering, AI and ML design and simulate biological systems [Garg, 2022; 2024] for diverse applications like biofuel production and pharmaceutical synthesis. Ensuring regulatory compliance and quality control involves analyzing data to predict potential issues.

While AI and ML hold immense promise, their success relies on reliable data. Implementation demands interdisciplinary collaboration among biologists, data scientists, and computer scientists. Ethical and regulatory challenges arise from handling sensitive biological data, necessitating the development of ethical guidelines. Rigorous validation is crucial before applying findings in practical applications. A study evaluated the feasibility of an AI-powered web-based clinical decision support system for treating depression in adults, employing a digital AI-powered CDSS.

Limitations

AI and ML technologies present various limitations, such as training complexities, heightened unemployment risks, challenges in managing substantial changes, dependency on explicit instructions, increased cybercrime threats, absence of human and social values integration, and a decision loop.

It is imperative to provide comprehensive training for medical professionals, ensuring accurate data for optimal AI and ML performance. Notably, the healthcare sector faces a potential rise in unemployment due to these technologies, necessitating a delicate balance across different sectors.

Striking this balance is crucial, given that pivotal decisions can significantly impact life and death situations.

While AI operates strictly on given instructions, humans possess a unique ability to observe behavioral changes and synchronize with patients, reducing complications. The escalating sophistication of cybercrimes underscores the need to safeguard patient credentials through AI to mitigate risks effectively.

The incorporation of human and social values into AI remains challenging. Despite AI's ability to offer appropriate treatment based on ML or diagnosis, it often overlooks inherent social values influencing decisions. Physicians, performing a broader range of tasks than AI algorithms, can adapt to various situations even with limited access to data.

Conclusion

The potential benefits of AI and ML technologies must be meticulously managed and adapted to ensure effectiveness and safety. This project explored their applications in biotechnology, healthcare, and genomics, emphasizing the importance of ethical, legal, and moral considerations. Raising awareness of AI and ML models across all societal segments, including rural populations, is essential. Establishing organizations and forums for regulating the ethical use of AI, with a primary focus on user privacy and data protection, is recommended. Future research should prioritize ethical and feasible levels of investigation into the applications of AI and ML in healthcare and biotechnology, drawing insights from experts and the general population while analyzing potential challenges for the future.

References

1. Garg, R. (2024). From Virtual World to Real Lives - 1: Sculpting New Realities with ML, AI, and IoT. Taylor & Francis, Routledge, Oxfordshire, UK. ISBN 978-10-3271-945-0.
2. Garg, R. (2022). Artificial Intelligence: Harnessing the Power of Human Mind. Scholars Park [Online]. Available at: https://scholarspark.wordpress.com/artificial-intelligence-2/ (Accessed: 30 Aug. 2023).
3. Garg, R. (2021). Decoding Tomorrow: Traversing the Landscape of Artificial Life. Scholars Park [Online]. Available at: https://scholarspark.wordpress.com/2021/04/21/example-post-3/ (Accessed: 30 Aug. 2023).
4. Illumina. (2023). Machine-learning tools in TruSight Software Suite. Available at: https://www.illumina.com/content/dam/illumina/gcs/assembled-assets/marketing-literature/trusight-software-suite-machine-learning-app-note-m-gl-00008/trusight-software-suite-machine-learning-app-note-m-gl-00008.pdf (Accessed: 31 Aug. 2023).
5. Intuitive. (2023). About da Vinci Systems. [Online]. Available at: https://www. intuitive.com/en-us/patients/da-vinci-robotic-surgery/about-the-systems (Accessed: 31 Aug. 2023).
6. Jumper, J., Evans, R., Pritzel, A., Green, T., Figurnov, M., Ronneberger, O., Tunyasuvunakool, K., Bates, R., Žídek, A., Potapenko, A., Bridgland, A., Meyer, C., Kohl, S.A.A., Ballard, A.J., Cowie, A., Romera-Paredes, B., Nikolov, S., Jain, R., Adler, J. and Back, T. (2021). Highly accurate protein structure prediction with AlphaFold. Nature, 596(7873), pp. 583–589.
7. Microsoft. (2023). Project InnerEye - Democratizing Medical Imaging AI. [Online]. Available at: https://www.microsoft.com/en-us/research/project/medical-image-analysis/ (Accessed: 31 Aug. 2023).
8. Nvidia (2023). Clara Parabricks v4.0.1. [Online]. Available at: https://docs. nvidia.com/clara/parabricks/4.0.1/index.html (Accessed: 31 Aug. 2023).

9. Pfizer.com. (2016). IBM and Pfizer to Accelerate Immuno-oncology Research with Watson for Drug Discovery | Pfizer. [Online]. Available at: https://www.pfizer.com/news/press-release/press-release-detail/ibm_and_pfizer_to_accelerate_immuno_oncology_research_with _ watson_for_drug_discovery (Accessed: 31 Aug. 2023).

10. Zymergen. (2023). Programming Microbes. [Online]. Medium. Available at: https:// medium.com/@ZymergenTechBlog/programming-microbes-fa8b2cca1aab (Accessed: 31 Aug. 2023).

IEHE The Quest | Volume II | 2023.

Issue 2: Pages 36-41.

ADITYA L1: Illuminating Insights and Innovations - A Review

Jayant Nagle and Pragyesh Kumar Agrawal

Department of Physics and Electronics
Institute for Excellence in Higher Education (IEHE) Bhopal, M.P. India

Abstract

This paper reviews the first Indian Space based observatory “Aditya L1”, which aims to study the Sun from a halo orbit around first Sun-Earth Lagrange Point (L1). Here we will discuss the mission in detail including its trajectory to L1, objectives, need, insights and indigenously developed scientific payloads.

Introduction

We, Homo-Sapiens are so much curious about the universe and its wonders. One of such wonders are stars, that twinkle in the night sky. Although we have studied so much about them but stil we are far to understand them completely. One of such stars is our Sun and to understand it we have sent 23 missions[1] including PIONEER 5[1], 1960 (first mission to sun by NASA) to recent missions such as Parker Solar Probe (NASA,2018)[1], Solar Orbiter (ESA,2020)[1], CuSP (NASA, 2022)[1] and Aditya L1 (ISRO, 2023)[1].

Aditya L1 mission was originally announced in January, 2008[2] by the name of Aditya 1 because Aditya means Sun in Sanskrit language and initially it was aimed to place the observatory in 800 km low Earth orbit but later ISRO decided to place it in a large halo orbit around Sun-Earth Lagrange point 1, which in turn led to change the name of Aditya 1 to Aditya L1[2].

Aditya L1 was successfully launched on September 02, 2023 at 11:50 AM IST via Polar Satellite Launch Vehicle from the second launch pad of Satish Dhawan Space Centre, Shriharikota, Andhra Pradesh[3].

This mission aims to provide crucial information to understand the problems of exceptional coronal heating, coronal mass ejection, pre and post flare activities, dynamics of space weather and fields in interplanetary medium by revolving in a halo orbit around Lagrange Point 1 with its seven scientific payloads. We will discuss all of this in details in the following sections.

Description

The Sun

Sun is the nearest star from earth and largest object in our Solar system which makes up about 99.86% of the total mass of the solar system[4]. Estimated age of the Sun is about 4.57 billion[5] years. It is a hot object consisting of hydrogen and helium gases and located around 150 million km from earth.

The core temperature of Sun is about 15 million Degree Celsius[6] whereas the visible surface known as Photosphere is relatively cool having temperature of about 5500 Degree Celsius[6] and weirdly the atmosphere of Sun known as Corona as hot as 2 million Degree Celsius[6] and this is still a mystery for scientific community because in general temperature goes down with respect to surface on increasing the distance.

Need

The first and foremost question arises to our mind is that why we need to study the Sun?

Answers are as follows:

- Since Sun makes up 99.86% mass of the total mass of solar system, so it is impossible to understand the Solar System without understanding the Sun[7].
- The Sun is nearest star from Earth and therefore, can be studied in much more details as compared to other stars. These studies are expected to help us understand distant stars and galaxies too.
- By understanding the exceptional Coronal heating with respect to Photosphere, we can understand Coronal mass ejection (CME) and other eruptive phenomena which directly affect Earth's magnetic field and communication systems.
- Various thermal and magnetic phenomena on Sun are of extreme nature[6] (that can't be created on Earth) thus it provides a natural laboratory for study such phenomena.
- The earliest life forms we know of were microbes that left their signal of presence in rocks about 3.7 billion years ago[8], and the estimated age of our Sun is 4.57 billion[5] years but it contradicts the fact that 3.7 billion[8] years ago the Sun did not have that much amount of heat[9] to sustain water in liquid form in the oceans of the Earth, and we know that life first started developing in oceans.
- By understanding the Sun and its eruptive phenomena we can take corrective measures against Carrington event[9] (i.e., disruption of telegraph lines and power grids as observed in 1859) and Kessler Syndrome[9](malfunctioning of satellites which can lead to create huge space debris and badly affect our communication systems).

Lagrange Points

Lagrange points are some specific points in space where the gravitational pull of two large bodies equals to the necessary centripetal force required for a small object to move with them. These points act as parking spots for probes and can be used by the spacecrafts to remain at around this point with less fuel consumption, longer life, stability for smooth conduction of experiments and continuous signal transmission to the Earth.

As per plan Aditya L1 will be placed in a Halo orbit around Lagrange Point 1 and conduct experiments for five years[10].

Insights

Why not from the Earth?

Earth's magnetic field doesn't allow the solar storms to enter the atmosphere of Earth. Also, Earth's atmosphere filters out most of the radiations from the Sun and hence, life is flourishing on Earth. This in turn leads to the loss of lots of information regarding the Sun and hence, we can't understand and study it efficiently.

Why L1?

As shown in figure 1, there are five Lagrange Points to the Sun-Earth system two of which (viz. L4, L5) were discovered by Lagrange in 1772[11]. These points are far away as compared to L1. Other three Lagrange points (viz. L1, L2, L3) were discovered by Euler around 1750[11] from which L3 is always behind the Sun with respect to Earth, L2 is located towards Mars and therefore at that point there will be eclipses from the Earth and Moon. Therefore we are left with L1 which is closure towards the Sun and there are no eclipses at this point and hence we can continuously observe the Sun from here.

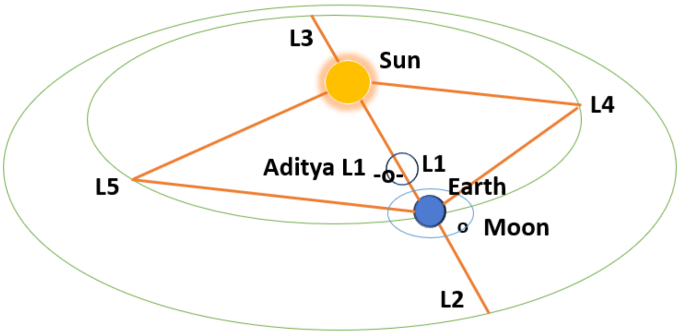


Fig. 1: Illustration of Lagrange Points

The mission: ADITYA L1

Aditya L1 is first Indian Space based observatory to study the Sun with major objectives[12] as follows:

- Study the solar upper atmospheric (Chromosphere and Corona) dynamics.
- Study the Chromosphere and Coronal heating physics of partially ionized plasma and initiation of coronal mass ejection.
- Study the magnetic field topology and magnetic field measurement in the solar Corona.
- Study the development, dynamics and origin of Coronal mass ejection.
- Diagnostic of coronal and coronal loops plasma: temperature, velocity, density.
- Identify the sequence of processes that occur at multiple layers (i.e., Chromosphere base and extended Corona)
- Observe in-situ particles and plasma environment and provide data for the study of particle dynamics from the Sun.
- Study of physics for solar Corona and it's heating mechanism.
- Study of drivers for space weather (origin, composition and dynamics of solar wind).

Payloads

For all of the mentioned objectives, Aditya L1 is onboard with seven scientific payloads [13] which are as follows:

1. fluxgate MAGnetometer[13] (MAG):

- It is a dual triaxial magnetic sensor.
- Major objectives:
- Measure magnitude and direction of interplanetary magnetic field (IMF)
- To study the Impact of extreme solar events in near Earth environment
- Its observations will be supplement to other onboard payloads such as PAPA and ASPEX

2. Visible Emission Line Coronagraph[13](VELC):

- It is designed as an internally occulated reflective coronagraph.
- Major objectives:
- Simultaneous observation of solar corona in three modes i.e., Imaging, Spectroscopy and Spectro-polarimetry.
- Diagnostics of coronal and coronal loops plasma (temperature, velocity, density)
- To work as onboard Artificial Intelligence (AI) for the detection of coronal mass ejection.

3. High Energy L1 Orbiting X-ray Spectrometer[13](HEL1OS)

- HEL1OS is pronounced as Helios.
- It is a hard X-ray spectrometer designed to observe solar flares in X-ray energy range of 10-150 keV.
- Major objectives:
- To study the explosive energy release, acceleration and transportation of electron using high resolution spectra and fast timing measurements.
- To study the Quasi periodic pulsation of hard X-rays during impulsive phase of solar flares to understand its connection with particle acceleration mechanism.

4. Solar Low Energy X-ray Spectrometer[13](SoLEXS):

- It is a soft X-ray spectrometer to study the Sun.
- Major objectives:
- Continuously measure soft solar X-ray flux between energy range of 1keV to 22keV
- Study of solar flares and coronal heating.
- To independently measure the coronal temperature as well as abundances of coronal plasma

5. Solar Ultraviolet Imaging Telescope[13] (SUIT):

- It provides unique opportunity to study spatially resolved solar spectral irradiance in near ultra violet range.
- Major objectives:
- To study coupling and dynamics of solar atmosphere.
- Study of mechanisms responsible for stability, dynamics and eruption of solar prominences.
- To find out at what wavelength do flares radiate most of its energy.

6. Aditya Solar wind Particle EXperiment [13](ASPEX):

- It comprises low and high energy particle spectrometers to carry out in-situ measurement of solar wind particles near Lagrange point 1.
- Sub systems and their major objectives:
- Solar Wind Ion Spectrometer (SWIS): It is a low energy ion spectrometer which measures ion flux of protons and Alpha-particles in the energy range of 100eV. to 20keV.
- Supra thermal and Energetic Particle Spectrometer (STEPS): It is a high energy ion spectrometer which measures ion flux of protons and Alpha-particles in energy range of 20keV. to 5MeV.

7. Plasma Analyser Package for Aditya[13](PAPA):

- It aims to study the composition of solar wind and its energy distribution.
- Sub systems and their major objectives:
- Solar Wind Electron Energy Probe (SWEEP): Consists of two guiding plates for directing the electrons and ions of solar flares for further energy analysis and smoothening the signal.
- Solar Wind Ion Composition AnalyseR (SWICAR): Used for energy and mass analysis of ions and electrons of solar flares.

Trajectory

Aditya-L1 was launched on September 02, 2023 at 11:50 AM I.S.T. by ISRO PSLV C57 rocket from the second launch pad of Satish Dhawan Space Centre (SDSC), Sriharikota. Initially the spacecraft was placed in a low earth orbit. Subsequently, the orbit was made more elliptical and later the spacecraft was launched towards the Lagrange point L1 by using on-board propulsion. As the spacecraft travels towards L1, it exited the earth's gravitational Sphere of Influence (SOI) (as per the data of September 30, 2023) [14]. After the exit from SOI, the cruise phase is started and subsequently the spacecraft would be injected into a large halo orbit around L1. The total travel time from launch to L1 would take about 127 days[3] for Aditya L1.

Analysis

- Aditya L1 is important for scientific communities because it is crucial for understanding the coronal mass ejection and its impact on space weather and Earth, which in turn comes out to be important mission to save life on Earth.
- With International collaborations like National Aeronautics and Space Administration (NASA)'s Parker Solar Probe and European Space Agency (ESA)'s Solar orbiter enhances data sharing and global understanding of the Sun.
- Aditya L1 enhances India's standing in the global space community and strengthens diplomatic ties with space faring nations.
- It also demonstrates India and ISRO's technological capabilities and its ability to undertake complex space missions.
- Last but not the least, Aditya L1 mission will act as an inspiring tool for the next generations of youth, scientists and engineers in India and beyond.

Conclusion

Space researches were the part and parcel of ancient Indian education but its scientific advancement hindered significantly during colonial rules. These researches again started in 1920's when scientist Dr. S.K. Mitra performed series of experiments on ionosphere and radio waves from Kolkata[15], and in almost 100 years India is again setting milestones in this field by launching "Mangalyaan", "Chandrayaan-1, 2, 3" and "Aditya L1".

This review paper delved into various aspects of the mission including its objectives, instrumentation, trajectory and anticipated contribution to space science. With its cutting-edge instrumentation and international collaborations, the mission promises to provide valuable insights into solar dynamics, understanding the Sun and its eruptive phenomena, space weather and impact of coronal mass ejection on Earth.

As we look forward to the mission's data and discoveries, it is clear that Adiya L1 will stand as a testament to India and its growth in space research. It will undoubtedly strengthen its commitment towards advancing our understanding of the cosmos.

References

1. Wikipedia contributors. (2023, October 1). List of Solar System probes. Wikipedia. https://en.wikipedia.org/w/index.php?title=List_of_Solar_System_probes&oldid=1178069878 .
2. Aditya L1 mission- India's First Solar Mission. (2023). BYJU's. https://byjus.com/free-ias-prep/aditya-mission/ .
3. Indian Space Research Organisation. (2023, September 2). Successful Launch of PSLV-C57 with Aditya-L1 spacecraft. Government of India, Department of Space, ISRO. https://www.isro.gov.in/PSLVC57_AdityaL1_PressRelease.html .
4. Sharp, T., & Harvey, A. (2022, January 21). How big is the sun? Space.Com. https://www.space.com/17001-how-big-is-the-sun-size-of-the-sun.html .
5. Sutter M., P. (2022, June 23). How Do We Know How Old the Sun Is? Discovery. https://www.discovery.com/science/how-old-is-the-sun- .
6. Indian Space Research Organisation. (2023, September). ADITYA L1 MISSION. Government of India, Department of Space, ISRO. https://www.isro.gov.in/media_isro/pdf/Aditya_L1_Booklet.pdf .
7. Venkateswaran, T. V. (2023, September 4). Aditya-L1: its functioning and purpose. The HINDU. https://www.thehindu.com/sci-tech/science/aditya-l1-its-functioning-and-purpose/article67269560.ece#:~:text=Aditya%20L1%20will%20join%20this,months%20before%20it%20reaches%20L1.
8. Koppes, S. (2022, September 19). The origin of life on Earth, explained. University of Chicago Office of Communications. https://news.uchicago.edu/explainer/origin-life-earth-explained#:~:text=Scientists%20think%20that%20by%204.3,only%203.7%20billion%20years%20old.
9. Kaushik. (2023, September 3). Why Aditya L1 is most important mission for ISRO. अंतरिक्ष T.V. ,YouTube. https://youtu.be/TRQkewkOjco?si=u0rZWwYTvZnPHc2V .
10. Indian Space Research Organisation. (2023, September). PSLV-C57/Aditya-L1 Mission. Government of India, Department of Space, ISRO. https://www.isro.gov.in/Aditya_L1.html .
11. Wikipedia contributors. (2023, October 19). Lagrange point. Wikipedia, The Free Encyclopedia. https://en.wikipedia.org/w/index.php?title=Lagrange_point&oldid=1180813561 .
12. Indian Space Research Organisation. (2023, September). PSLV-C57/Aditya-L1 Mission. Government of India, Department of Space, ISRO. https://www.isro.gov.in/Aditya_L1.html .
13. Indian Space Research Organisation. (2023, September). ADITYA-L1 Payloads. Government of India, Department of Space, ISRO. https://www.isro.gov.in/Aditya_L1_Payload.html .
14. BUREAU, T. H. (2023, September 30). Aditya-L1 space craft escapes sphere of Earth's influence. THE HINDU. https://www.thehindu.com/sci-tech/science/indias-aditya-l1-spacecraft-successfully-escapes-sphere-of-earths-influence/article67366385.ece .
15. Wikipedia contributors. (2023, October 11). ISRO. Wikipedia, The Free Encyclopedia. https://en.wikipedia.org/w/index.php?title=ISRO&oldid=1179584477 .

IEHE The Quest | Volume II | 2023.
Issue 2: Pages 42-48.

भारत का संघीय स्वरूप एवं गठबन्धन की राजनीति

साधना पाण्डेय एवं राज कुमार कुशवाहा
राजनीति विज्ञान विभाग
उच्च शिक्षा उत्कृष्टता संस्थान(IEHE), भोपाल, म.प्र. भारत

शोध आलेख सारांश

भारत की भौगोलिक एवं सांस्कृतिक विविधता को ध्यान में रखते हुये भारतीय संविधान निर्माताओं ने भारत के लिये संघीय संविधान का निर्माण किया। भारतीय संविधान के प्रथम अनुच्छेद में ही 'भारत को राज्यों का संघ' कहा गया है। संविधान में संघात्मक स्वरूप के सभी बुनियादी लक्षणों को शामिल करते हुये देश की एकता और अखण्डता को सुनिश्चित करने के लिये एकात्मक लक्षणों को भी स्थान दिया गया है। संघीय स्वरूप के साथ ही बहुदलीय प्रणाली को भी अपनाया गया है। बहुदलीय प्रणाली में एकदलीय स्पष्ट बहुमत की सरकारों के साथ ही बाद की परिस्थितियों में गठबन्धन की सरकारें भी केन्द्रीय एवं राज्य दोनों स्तरों पर निर्मित एवं संचालित हुयीं। दोनों ही सरकारों के समक्ष अलग-अलग प्रकार की चुनौतियाँ बनती रहीं, लेकिन एक आम सहमति बनाकर विविध क्षेत्रों एवं समुदायों का प्रतिनिधित्व सुनिश्चित करने और सर्वसम्मति आधारित निर्णय लेने को बढ़ावा देने में गठबन्धन की सरकारें अधिक महत्वपूर्ण भूमिका निभा सकती हैं।

भारतीय संविधान की मुख्य विशेषताओं में से एक भारत का संघीय स्वरूप है। भारतीय संविधान के प्रथम अनुच्छेद में उल्लेखित है कि 'भारत राज्यों का मेल' होगा। भारतीय संविधान में संघीय व्यवस्था की सभी आवश्यक विशेषताओं को अपनाया गया है लिखित एवं कठोर संविधान, संघ एवं राज्यों के मध्य शक्तियों का विभाजन, स्वतन्त्र एवं सर्वोच्च न्यायपालिका।

यद्यपि संविधान द्वारा केन्द्र एवं राज्यों के मध्य तीन सूचियों द्वारा शक्तियों का स्पष्ट विभाजन किया गया है किन्तु व्यवहारिक रूप से संविधान में कुछ ऐसे प्रावधान भी हैं जिनके द्वारा केन्द्र सरकार राज्य सरकारों की विधायी शक्ति में हस्तक्षेप कर सकती है। उदाहरण स्वरूप संविधान के अनुच्छेद 249 के अनुसार यदि राज्यसभा अपने उपस्थित एवं मत देने वाले सदस्यों के दो तिहाई बहुमत से प्रस्ताव पास करें कि राष्ट्रहित में यह हितकर है तो संसद राज्यसूची के विषय पर कानून बना सकती है। भारतीय संघात्मक व्यवस्था की कमियों को दूर करने की दृष्टि से ही भारत के संघीय शासन में एकात्मक स्वरूप के कुछ लक्षणों को भी स्वीकार किया गया है, इसलिये कहा जाता है कि भारतीय संविधान का स्वरूप संघात्मक है और आत्मा एकात्मक है।

भारत की राजनीतिक परिस्थितियों में परिवर्तन के साथ-साथ संघीय स्वरूप में भी परिवर्तन स्पष्ट दिखायी देता है, जिन्हें हम संक्षेप में चार प्रकारों में चिन्हित कर सकते हैं:-

(1) **केन्द्रीयकृत संघवाद का युग** - 1950 से 1967 तक का समय भारतीय राजनीति में केन्द्रीयकृत संघवाद के युग के रूप में समझा जा सकता है। केन्द्र तथा राज्यों में कांग्रेस का एकछत्र शासन था अतः मतभेदों को दल के संगठन स्तर पर ही हल कर लिया जाता था।

(2) **सहयोगी संघवाद का युग** - 1967 के चतुर्थ आम चुनाव के पश्चात शक्ति संतुलन राज्यों की तरफ झुका। राज्यों में गैर कांग्रेसी सरकारों का गठन हुआ। केन्द्र एवं राज्यों के मध्य विवादों के उपरान्त भी सहयोग बना रहा । सहयोगी संघवाद का प्रमुख लक्षण केन्द्र और राज्यों की सरकारों की एक दूसरे पर निर्भरता रही।

(3) **एकात्मक संघवाद का युग** - 1971 के पाँचवें लोकसभा चुनाव से भारतीय राजनीति में श्रीमती इंदिरा गाँधी सर्वमान्य नेतृत्व के रूप में स्थापित रहीं। जून 1975 से मार्च 1977

तक भारतीय राज्य एकात्मक राज्य में परिवर्तित हो गया। सम्पूर्ण शक्तियाँ केन्द्रीय सरकार के पास समाहित हो गयीं थीं।

(4) **गठबन्धन (सौदेबाजी) संघवाद का युग** - छठवें आम चुनाव (1977) से भारतीय राजनीति में नवीन परिवर्तन आया। केन्द्र में जनता पार्टी की सरकार स्थापित हुयी और राज्यों में भी अलग-अलग दलों की सरकारें स्थापित हुयीं।

1989 से 1999 के मध्य के चुनावों से यह प्रतीत होता है कि भारत में संघीय व्यवस्था का सौदेबाजी वाला प्रतिमान ही कार्यरत था। श्री विश्वनाथ प्रताप सिंह (1989), श्री

चन्द्रशेखर (1990), श्री पी.वी. नरसिम्हाराव (1991), श्री एच.डी. देवगौड़ा (1996) तथा श्री इन्द्र कुमार गुजराल के नेतृत्व में बनने वाली सभी केन्द्रीय सरकारें अल्पमतीय सरकारें थीं, जिन्हें सत्ता में बने रहने के लिये उन दलों का सहयोग लेना पड़ा जो राज्यों में शक्ति में थीं। अनेक राज्यों में क्षेत्रीय दलों की सरकारें थीं जिनके सहयोग पर केन्द्रीय सरकार टिकी हुयी थी तथा कई विषयों पर इन सहयोगी दलों ने केन्द्र से सौदेबाजी भी की। भारतीय राजनीति में गठबन्धन की केन्द्रीय सरकारों को कई अवसरों पर क्षेत्रीय दलों की सरकारों के दबाव में रहना पड़ा तथा प्रत्येक क्षेत्रीय दल केन्द्रीय सरकार को समर्थन देने के बदले में अपने क्षेत्र (राज्य) के लिये विषेष सुविधाओं की माँग भी कर रहा था।

कुल मिलाकर हम यह समझने का प्रयास करेंगे कि भारत का संघीय स्वरूप और गठबन्धन की राजनीति एक साथ कैसे कार्य करते हैं।

भारत में बहुदलीय राजनीतिक प्रणाली के कारण गठबन्धन की सरकारें एक सहज राजनीतिक व्यवस्था है। गठबन्धन सरकारों को विविध राजनीतिक दलों से विचार- विमर्श करने और एक सामान्य न्यूनतम कार्यक्रम या समझौते की आवश्यकता होती है जो उनके साझा एजेंडे और नीतियों (मुद्दों) को रेखांकित करता हो। यह समझौता राजनीतिक स्थिरता बनाये रखने तथा यह सुनिश्चित करने में मदद करता है कि गठबन्धन सहयोगी अपने वैचारिक मतभेदों के बावजूद एक साथ काम करते हैं। इस प्रकार की गठबन्धन सरकारें केन्द्र

में तथा राज्यों (दोनों) में भी निर्मित होती हैं। इस शोध आलेख में हम केन्द्र में गठबन्धन सरकारों के सन्दर्भ में भारत के संघीय स्वरूप का अध्ययन कर रहे हैं।

भारत में गठबन्धन सरकारों के कार्यकलापों की यदि समीक्षा की जाये तो यह स्पष्ट होता है कि प्रायः राजनीतिक दलों की अलग-अलग प्रकृति और गठबन्धन सहयोगियों के मध्य आम सहमति की आवश्यकता के कारण उन्हें कई चुनौतियों का सामना करना पड़ता है।

प्रथमतः गठबन्धन सरकार में सरकार की स्थिरता बनाये रखने के लिये दलों को नीतिगत निर्णयों से समझौता भी करना पड़ता है। उदाहरण स्वरूप भारतीय राष्ट्रीय कांग्रेस के नेतृत्व वाली संयुक्त प्रगतिशील गठबन्धन (यूपीए) सरकार को गठबन्धन सहयोगियों के मध्य मतभेदों के कारण आर्थिक सुधारों को लागू करने में कई चुनौतियों का सामना करना पड़ा। द्वितीय भारत विशिष्ट राज्यों (क्षेत्रों) को प्रतिनिधित्व करने वाले क्षेत्रीय दलों के साथ एक विविधतापूर्ण देश है। गठबन्धन सरकारों को प्रायः इन क्षेत्रीय आकांक्षाओं और मांगों को भी पूरा करना पड़ता है। इसके अतिरिक्त, गठबन्धन सरकारें प्रायः सत्ता विरोधी भावनाओं और चुनावी दबावों का भी सामना करती है, विशेष रूप से तब जब सरकारें अपने चुनावी वादों को पूरा करने या जनता की समस्याओं का निवारण करने में असमर्थ होती हैं। लेकिन यह भी एक महत्वपूर्ण तथ्य है कि गठबन्धन सरकारों के समक्ष आने वाली चुनौतियाँ

किसी विशेष राजनीतिक दल या सरकार से जुड़ी नहीं हैं, ये भारत जैसे विविधतापूर्ण लोकतन्त्र में गठबन्धन राजनीति की गतिषीलता में निहित है।

इन चुनौतियों के साथ भारत के संघीय स्वरूप में गठबन्धन की राजनीति कुछ सकारात्मक पहलुओं को भी सामने लाती है। मुख्यतः गठबन्धन सरकारों में विविन्न क्षेत्रों, समुदायों और हितों का प्रतिनिधित्व करने वाले दल सम्मिलित होते हैं, इसलिये यह शासन को अधिक समावेशी और प्रतिनिधि स्वरूप की तरफ प्रवृत्त करता है। दूसरे, गठबन्धन सरकारें नीतिगत विषयों पर एक आम समझौते तक पहुँचने के लिये बातचीत और अन्ततः समझौते और सहमति को प्रात्साहित करती है। उदाहरण स्वरूप भारतीय जनता पार्टी के नेतृत्व वाली राष्ट्रीय जनतान्त्रिक गठबन्धन (एनडीए) सरकार ने क्षेत्रीय दलों को शामिल करते हुए केन्द्र में एक गठबन्धन सरकार को सफलतापूर्वक प्रबंधित एवं संचालित किया। सरकार संवाद और बातचीत के माध्यम से प्रमुख नीतिगत निर्णयों पर आम सहमति बनाने में सक्षम रही है। एक संघीय व्यवस्था वाले देश भारत में गठबन्धन सरकारें क्षेत्रीय विकास और सहयोग पर भी अधिक ध्यान केन्द्रित करने को प्रोत्साहित करती हैं।

अन्ततः निष्कर्ष रूप में हम यह कह सकते हैं कि भारत के संघीय स्वरूप में गठबन्धन सरकारें अपनी विभिन्न चुनौतियों के बावजूद विविध राजनीतिक हितों को समायोजित करने, विभिन्न क्षेत्रों और समुदायों का प्रतिनिधित्व सुनिश्चित करने और सर्वसम्मति आधारित निर्णय लेने को बढ़ावा देने में महत्वपूर्ण भूमिका का निर्वहन करती हैं। यद्यपि उन्हें प्रभावी समन्वय और संवाद की आवश्यकता होती है, लेकिन गठबन्धन सरकारें एकदलीय सरकारों की तुलना में अधिक समावेशी और संतुलित शासन प्रणाली में योगदान करती हैं। यह सही है कि संघीय स्वरूप में गठबन्धन सरकारों की सफलता, इसमें शामिल

दलों की एक सामान्य कार्यसूची बनाने, परस्पर एकता बनाये रखने और सम्पूर्ण राष्ट्र और उसकी जनता की भलाई की दिशा में कार्य करने की सोच एवं क्षमता पर निर्भर करती है।

सन्दर्भ सूची :-

1. ए.एस. नारंग, "भारतीय शासन एवं राजनीति" गीतान्जलि पब्लिशिंग हाऊस, पृष्ठ 74.
2. नवीन कुमार अग्रवाल, "भारत की राजनीतिक व्यवस्था" , ज्ञानदा प्रकाशन, नयी दिल्ली, पृष्ठ 231.
3. टी.पी. जोशी एवं आर.एस. आढा, "भारतीय राजनीतिक व्यवस्था: पुर्नरचना के विविध आयाम" , रावत पब्लिकेशंस, जयपुर, पृष्ठ 53.