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प्रकृति में एक आकर्षक इंद्रधनुष

Eddy-covariance Tower at Kaziranga National Park in Assam

On the way to the Eddy-covariance Tower site at Kaziranga National Park in Assam

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बारिश के बाद आसमान में सात रंगों की बनी खूबसूरत आकृति को इंद्रधनुष कहते हैं। बरसात के मौसम में बारिश के बंद होने के बाद जब सूर्य की किरणें बादलों से टकराती हैं तो आकाश में रंग-बिरंगी आकृति दिखाई देती है। यही आकृति इंद्रधनुष कहलाती है। बरसात के मौसम में जब पानी की बूंदें सूर्य की किरणों पर पड़ती हैं, तब सूर्य की किरणों का विक्षेपण ही इंद्रधनुष के सुंदर रंगों का कारण बनता है। आसमान में शाम के समय पूर्व दिशा में और सुबह पश्चिम दिशा में, बारिश के बाद लाल, नीला, पीला, हरा, आसमानी, नीला और बैंगनी रंगों का वृत्ताकार चक्र जैसा कभी-कभी दिखाई देता है। ये ही सप्तरंगी इंद्रधनुष है। सोचो अगर हमारे जीवन में रंग न होते तो हमारी जिंदगी कितनी बदरंग होती। सब चीजें काली या सफेद ही होतीं। मूल रूप से इंद्रधनुष के सात रंगों को ही रंगों का जनक माना जाता है। रंगों की उत्पत्ति का सबसे प्राकृतिक स्रोत सूर्य ही है। सूर्य की किरणों में सात रंग होते हैं। ये सात रंग हैं- **बैंगनी, जामुनी, नीला, हरा, पीला, नारंगी और लाल**।

पहला रंग प्यार का ,
दूसरा रंग सदभाव का,
तीसरा रंग कर्म का,
चौथा रंग परोपकार का,
पांचवा रंग न्याय का,
छठा रंग समरसता का ,
सातवां रंग ख़ुशी का ||
सात रंग सपनों के,
सात रंग ज़िंदगी के ,
सात रंगों से बनता है , खुशियों का **इंद्रधनुष** ||

बैंगनी रंग का नाम एक सब्जी बैंगन के नाम पर रखा गया है। इसे अंग्रेजी में वॉयलेट कहते हैं, जो इसी नाम के फूल से रखा है। वॉयलेट रंग, बैंगनी रंग का हल्का शेड होता है। बैंगनी रंग रॉयलिटी, लग्जरी और वेल्थ का रंग हैं। ये रंग लाल और नीले रंग के मेल से बनता है।

प्रकृति में एक आकर्षक इंद्रधनुष

जामुनी रंग का नाम जामुन फल के नाम पर रखा गया है। ये बहुत ही गहरा रंग है। ये रंग हमें विराट होने का एहसास कराता है। जामुनी रंग रीगल (शाही) रंगों की सूची में आता है। जामुनी रंग कहता है कि हमें इस बड़ी सी दुनिया में बहुत बड़ा बनना है यानी अपना नाम रोशन करना है। **नीला रंग** आसमान और सागर दोनों का रंग नीला होता है। नीला रंग ठंडा रंग माना जाता है। नीला रंग हमें शांत, भरोसेमंद, वफादार और अपने जीवन में स्थिरता लाने की शिक्षा देता है। नीला रंग हमें सिखाता है कि हमें किसी भी परिस्थिति में अपना नियंत्रण नहीं खोना चाहिए और हर काम ठंडे दिमाग से करना चाहिए। **हरा रंग** हरियाली का प्रतीक माना जाता है। हरा रंग वसंत के आने यानी नए जीवन का सूचक होता है। घनी सर्दियों के बाद बाग-बगीचों, पेड़-पौधों पर फिर से एक बार हरियाली नजर आने लगती है। हरा रंग हमें सिखाता है कि हमें अपने जीवन को रोज एक नई उमंग, उत्साह और धैर्य के साथ जीना चाहिए। **पीला रंग** चमकदार और सुंदर रंग है। यह सूर्य का रंग है, जो प्रतीक है जीवन और रोशनी का। यह रंग हंसमुख है। स्वच्छ और उज्जवल है। स्पष्टता और जागरूकता की शिक्षा देता है। यह ऊर्जा का प्रतीक है। **नारंगी रंग** सुबह-सुबह के सूरज का रंग हैं। जिस तरह सूरज सुबह-सुबह निकलकर हमें उजाला देता है, उसी तरह ये रंग आस और विश्वास का प्रतीक है। यह हमें सिखाता है कि अंधेरे के बाद रोशनी जरूर आती है। **लाल रंग** रक्त का रंग है। ये वीरता, साहस और शौर्य का प्रतीक होता है। जिस तरह सबके लहू का एक ही लाल रंग होता है, उसी तरह लाल रंग सिखाता है कि हमें बिना किसी भेदभाव के सभी के साथ प्यार से रहना चाहिए। इंद्रधनुष हमें हमारी प्रकृति का दिया हुआ सबसे खूबसुरत तोहफों में से एक है। हमारे इतिहास में भी ऐसी कोई कहानियां नहीं हैं जो इंद्रधनुष के बारे में हमें कुछ बता सकें। इंद्रधनुष के बनने का कारण हम सबने अपनी स्कूल की किताबों में पड़ा ही है। इसके तहत तेज बारिश (**मौसम विज्ञान**) के बाद पानी के कुछ अणु वातावरण में जीवंत रहते हैं। ऐसे में जब सूर्य का प्रकाश इन

अणुओं से होकर गुजरता है, तो आसमान में अलग-अलग रंगो को बिखेरता (**भौतिक विज्ञान**) है। इस कारण हमें इन्द्रधनुष में लाल, हरा, पीला, नीला व अन्य सात रंग नजर आते हैं। दूसरे शब्दों में कहें तो यदि वातावरण में जल के अणुओं की पर्याप्त मात्रा हो और प्रकाश भी अनुकुल हो, तो हमे सात रंगो का इंद्रधनुष देखने का मौका मिल सकता है। यहां तक तो ठीक है, लेकिन कुछ लोग ऐसा भी मानते हैं कि इन्द्रधनुष केवल एक ही तरह का होता है, जो कि सही नहीं है, क्योंकि इन्द्रधनुष के कई प्रकार है : **प्राइमरी इंद्रधनुष**, **डबल इंद्रधनुष**, **ऐलेक्स ज़ैनडर्सडार्क इंद्रधनुष**, **सुपरनु मेरेरी इंद्रधनुष**, **रेड इंद्रधनुष** और **टविंड इंद्रधनुष** I भारत में इंद्रधनुष को वर्षा ऋतू में देखा जा सकता है | **इंद्रधनुष मौसम विज्ञान और भौतिक विज्ञान की सात रंगों की एक संयुक्त और आकर्षक रचना है** |

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Carbon cycle study in the Kaziranga National Park reveals a unique characteristic of the prevailing forest ecosystem

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Modern-day societies are surrounded by many complex but intriguing scientific applications. Most of these applications offer enormous potential to better our future, although there are few curses associated with these. Global warming is one of the most serious threats in the modern times caused by heavy industrialization and associated fossil fuel emission in the last 200 years.

One of the greatest threats of global warming is climate change mainly driven by the rise in greenhouse gases (GHGs), such as CO_2, CH_4, N_2O, etc., in the atmosphere, which due to their molecular structure trap an additional amount of radiation, in the longer wavelength zone of the electromagnetic spectrum. The most potent GHG is CO_2 whose concentration has increased at an alarming rate since the industrial revolution. For example, CO_2 level in 1750 was 280 ppm, recently crossed the 410-ppm mark (almost one and a half fold increase; Metya et al. 2021a) and still rising rapidly. For a better future, we need well-defined policies to contain the rising trend of CO_2 concentration; towards this we should have a precise knowledge of the CO_2 source and sink processes.

The enormous amount of CO_2 that is released into the atmosphere due to various anthropogenic activities is believed to be absorbed by the ocean and the terrestrial ecosystems approximately by a quarter by each of these carbon reservoirs. The amount of CO_2 uptake by the biosphere is still not well constrained on a global scale. Though these estimates are reasonably well constrained in advanced countries such as the USA, Europe, Japan, etc. the situation needs much improvement in India as well as other south Asian countries by obtaining the observational data through a robust network.

The bio-spheric flux of carbon dioxide is estimated by the imbalance between two large processes namely the photosynthetic sink and respiratory source. The amount of imbalance of these two opposing fluxes is added up to yield the net result, widely known as the Net Ecosystem Exchange or NEE. Currently, NEE is measured at hundreds of sites across the globe through a widely accepted technique, known as the **Eddy-Covariance (EC) technique** (Baldocchi et al., 2001).

The EC technique relies on the in-situ observations of various parameters and their covariance at a high frequency (10 Hz). Various state-of-the-art instruments are mounted on a tall tower at different heights that create a complex instrument cluster for observational purposes (Deb Burman et al., 2017; Deb Burman et al., 2019).

Various tall towers networks such as Fluxnet (global network), Ameriflux (in the USA), AsiaFlux (in a few countries in Asia), Ozflux (in Australia), ICOS (in Europe) etc. are operational across the globe. In India, the 'MetFlux India' endeavours to carry out similar micrometeorological observations in a few eco-systems (Chakraborty et al., 2020). Three major sites under the aegis of the 'MetFlux India' are- **Kaziranga National Park** (a semi-evergreen forest in Assam; Sarma et al., 2018; Sarma et al., 2019; Deb Burman et al., 2021), **Pichavaram** (a mangrove ecosystem in Tamil Nadu; Gnanamoorthy et al., 2019; Gnanamoorthy et al., 2020; Gnanamoorthy et al., 2021) **and Darjeeling** (an evergreen forest in north West Bengal; Chatterjee et al., 2018). The longest record (3 years, 2016-2018) is now available from the Kaziranga site.

A 50-meter-tall tower (**Figure 1a**) with an instrument cluster was erected in Kaziranga National park (26°34' 48" N latitude and 93°6' 28" E longitude) in 2015 (Deb Burman et al. 2017; Sarma et al. 2018). The sensors are powered by a solar panel 24×7 throughout the year. Routine data retrieval and maintenance of the tower site demand enormous effort and long human-working hours. Working in a national park, a natural habitat of wild animals is risky and even life-threatening. The situation becomes even worse during the monsoon season (**Figure 1b**). Every year during June, July, August and September when nearby Brahmaputra River the entire region gets inundated with about one-meter-high standing water. Continuous monitoring and maintenance of the site require efficient leadership and dedicated researchers with a high level of management skill, courage, and passion in pursuit of knowledge pertaining to the carbon sequestration process of the ecosystem.

Figure 1a: Eddy-covariance Tower at Kaziranga National Park in Assam

Figure 1b: On the way to the Tower site (at Kaziranga National Park in Assam).

In our current study, we have used the EC technique in association with stable carbon isotope measurements to get an independent way to calculate photosynthetic and respiratory fluxes.

One limitation of the EC setup is, it can only measure NEE; the individual components, such as, photosynthetic sink and respiratory source of carbon cannot be measured directly by the technique. The contributing components must be estimated if we want to know the total carbon balance of any ecosystem. We have one equation [NEE = P (photosynthesis) + R (respiration)] with two unknowns, i.e., a closure problem which may lead to multiple possible solutions. In absence of any biomass burning (as in the case of KNP, a pristine, protected national park), the night-time NEE can be considered as the addition of carbon due to the autotrophic (plant) and heterotrophic (animal respiration, biomass degradation, bacterial activity, etc.) respirations, while the daytime NEE results both from the photosynthesis and respiration processes. The widely used technique to solve this particular problem is to establish a functional relationship between the night-time NEE and the soil or air temperature, which is assumed to work for the daytime as well, and in turn, yields the daytime respiration component. Once the respiration component is found, the photosynthetic flux of CO_2 can also be estimated. Though this technique is widely used, it also has some limitations. David R. Bowling *(Professor of Biology, University of Utah*) argued that measuring the night-time NEE cannot be explained by temperature variation alone. Hence, such temperature-based fluxes do not necessarily provide a 'correct' means to estimate the respiration fluxes. Further, respiration flux cannot be used as a function of soil/air temperature only, as it can depend on plant physiology, radiation, rainfall, stand age, the height of a tree, type of seasons, etc.

Isotopes are the atoms of a given element that have the same atomic number but different masses. For example, carbon has two stable isotopes having masses of 12 and 13 respectively, measured in the atomic mass unit. Carbon in atmospheric CO_2 contains about 99% ^{12}C and only 1% ^{13}C. The intake of these two isotopes by the trees and plants is not the same. The photosynthesis process preferentially takes more $^{12}CO_2$ than $^{13}CO_2$. Thus, stable isotopes of carbon dioxide contain unique information about the biological and physical processes that exchange CO_2 between the terrestrial ecosystems and the atmosphere. Modern instruments, such as an isotope ratio mass spectrometer or a cavity ring-down spectrometer can precisely measure the changes in the $^{13}C/^{12}C$ ratio of atmospheric CO_2 caused by the plant biological and other physicochemical processes.

The isotopic ratio of leaf tissue of the C3 plants is nearly 2% less relative to atmospheric CO_2. Unlike the photosynthetic process, the respiration process does not discriminate the heavier isotopes so the isotopic ratio of respired CO_2 should reflect that of photo-assimilated carbon.

Since photosynthesis draws more $^{12}CO_2$, the daytime environment will be enriched in $^{13}CO_2$. On the other hand, the respiration process would release this $^{12}CO_2$ resulting in isotopic dilution of the ambient air. This is evident as a pronounced diurnal cycle in ^{13}C at the ecosystem scale. This unique property of stable isotope is used in association with the EC observation to construct two equations with two unknowns. The solutions of this equation give us the desired component fluxes.

The CO_2 concentration, as well as the isotopic profiles, were measured at the Kaziranga National Park in a campaign during February 2019 using a state-of-the-art greenhouse gas analyzer, Model: Picarro G2201-i. Picarro G2201-i is a modern-day GHG analyzer (**Figure 2**) based on cavity ring-down spectroscopy, which can measure the CO_2 and CH_4 concentrations and their $^{13}C/^{12}C$ isotopic ratios in real-time with high precision. Combined analysis of EC data and carbon isotopic measurements of the ambient air indeed shows that the technique of separating the photosynthetic and respiratory components is promising. The results have been recently published in Metya et al. (2021b).

Figure 2: **The Picarro greenhouse gas analyzer. It measures CO_2 and CH_4 concentrations, and their carbon isotopic ratios**.

Other instruments used are a sonic anemometer for wind speed measurements, Infrared Gas Analysers (IRGA) for atmospheric CO_2, and water vapor concentration measurement with a very high frequency (10 Hz) (Deb Burman et al., 2019). These instruments are called fast sensors as they quantify the mass exchange driven by turbulent processes necessitating high-frequency measurements. The next task is to process and analyze a large dataset, resulting from such fast measurements, continued for long durations, usually spanning over several seasons to years.

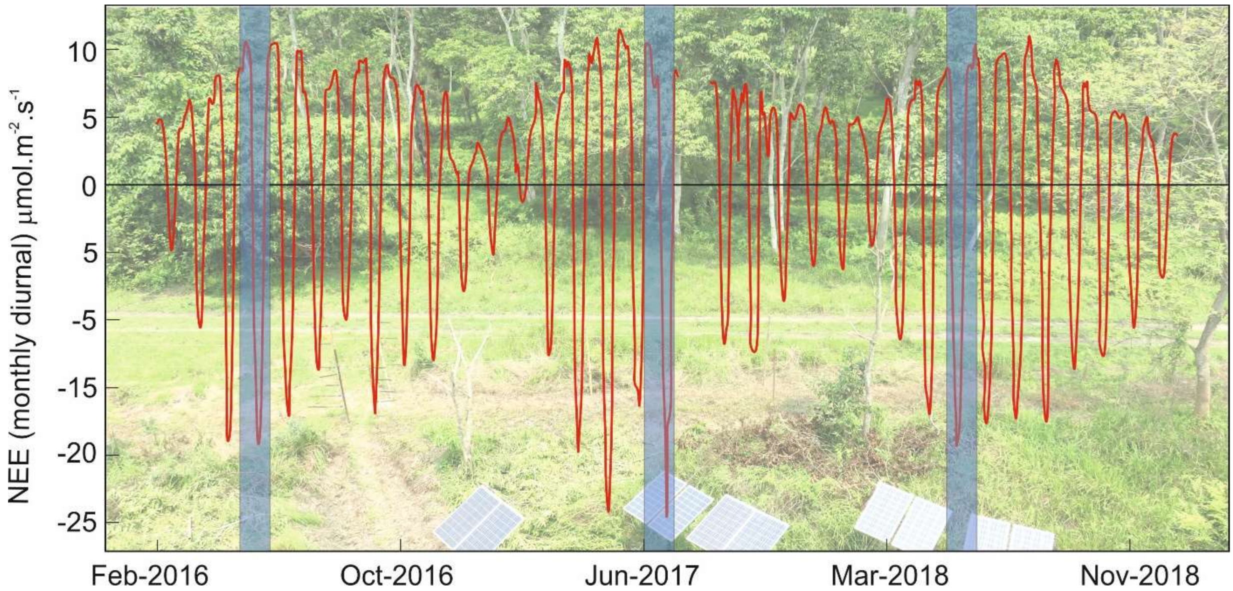

Figure 3: Atmosphere-biosphere carbon fluxes or the net-ecosystem exchange for the Kaziranga forest from February-2016 to December-2018. The maximum productivity was observed during the pre-monsoon time, shown as light grey shadings. The positive component of these fluxes arises because ecosystem respiration is significantly higher than in other Indian forests. The background shows the surrounding vegetation and the solar panels of the tower site.

The data analysis process demands high calculation power with high precision. The preliminary results show that the Kaziranga forest emits a significant amount of carbon presumably due to the soil respiration process. On the other hand, the carbon uptake by this forest is mainly restricted during the pre-monsoon season (Deb Burman et al., 2020). During April and May, this region receives sufficient rainfall driven by the thunderstorm activities which helps the vegetation to enhance their photosynthetic activities enabling them to draw a large amount of carbon from the atmosphere. **Figure 3** shows the diurnal variations of the NEE averaged on a monthly scale for the observational years of 2016 to 2018. The atmosphere to biosphere carbon uptake is maximum typically around May, shown as light grey shadings. Interestingly, the rate of this carbon uptake declines with the progress of the monsoon season, and during the winter months, the ecosystem emits more carbon into the atmosphere than it absorbs in these months. This is in sharp contrast to other forested areas of India, such as the teak forest in Madhya Pradesh which absorbs a huge amount of carbon during the post-monsoon to the winter season (Rodda et al. 2021). Most of the Indian forests act as a sink of carbon during the monsoon to post-monsoon time; the Kaziranga forest shows different behaviour. A high rate of soil respiration, as shown by the large positive component of the NEE in Figure 3, is believed to be the primary reason for such behaviour. North-east India is blessed with a large forest area, approximately 64%; so, it is expected to play a very important role in terms of absorbing the huge burden of CO_2 that is being dumped into the atmosphere due to the increased anthropogenic activities. The question remains whether the ecosystem is capable enough to absorb this burden. Only a better understanding of its carbon sequestration process through sustained observational work would answer this question.

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Computational Efficiency of Algebraic Operators

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An algebraic expression is a collection of algebraic operations represented by different operators and their operands. Algebraic operation is collection of Operator and its operands. Number of operands of an operator is called '**Arity of Operator**'. In some computer programming languages, arity of an operator is fixed and is variable in some programming languages. An operator is classified according to its arity. Operator of arity one is called '**Unary Operator**'. Operator of arity two is called '**Binary Operator**'. Operator of arity three is called '**Ternary Operator**'. Operator '**?:**' in ANSI C language is a ternary operator.

Humans evaluate an algebraic expression by scanning it again and again from left to right and during each such scanning, operator to be evaluated is located and evaluated and this operator may not be left most operator in the algebraic expression. After the evaluation of this operator, number of operators left to be evaluated decreases by one. This process is repeated again and again till all operators of the algebraic expression are evaluated. See the following example of one such process of evaluation of a simple algebraic evaluation.

Example of evaluation of an algebraic expression by humans

Given expression :	6 * (4 + 8) / 2 - (5 + 10) /5	
After next scanning :	6 * **12** / 2 – (5 + 10) / 5	**First Scanning.**
After next scanning :	6 * 12 / 2 – **15** / 5	**Second Scanning.**
After next scanning :	**72** / 2 – 15 / 5	**Third Scanning.**
After next scanning :	**36** – 15 / 5	**Fourth Scanning.**
After next scanning :	36 – **3**	**Fifth Scanning.**
After next scanning :	**33**	**Value of expression.**

Scanning of algebraic expression again and again is time consuming. This is so because in the given expression, position of an operator does not depend on the sequence of its evaluation. A need was therefore felt to have a different notation for an algebraic operation. Notation of an algebraic operation is expression of the operator and the collection of its operands. There can be three such notations for any algebraic operation. Algebraic operation can be expressed in three different forms. One of these forms of an operation leads to fastest execution among three forms and translator translates given algebraic expression appearing in a source code in to this form and evaluates the new form using data structure stack. Notation of an operation is classified according to the position of operator relative to its operands in the syntax of the algebraic operation. For addition operation A + B, operator symbol is + and A, B are its operands. Operator + can be placed (fixed) in three positions relative to its operands A and B, i.e., either before or after or in-between the collection of its operands. In 1951, a Polish (Native of Poland) logician and philosopher named **JAN LUKASIEWICZ** suggested that the operator can be placed before its operands, i.e., addition A + B can be expressed as +AB.

Jan Lukasiewicz
Polish Logician and Philosopher

Since the placement of operator before its operands was suggested by a native of Poland, this notation was therefore called **Polish Notation**. Natural extension of prefix notation was **Postfix Notation**. Polish notation is of two kinds depending on the arity of the operator. Polish notation is classified as '**Polish Prefix Notation**' if the arity of operators is fixed like in the language like in FORTRAN and '**Cambridge Polish Notation**' if the arity of operators in the language is variable like in programming language LISP. **Language LISP is used in designing artificial intelligence applications**. Postfix forms are evaluated by the computers using stack data structure.

(1) **Infix Notation**: Operation is said to be in 'Infix Notation' if operator is fixed in between its operands e.g. A + B is the infix notation for addition operation.

(2) **Polish Prefix Notation**: Operation is said to be in 'Prefix Notation' if operator is fixed before its operands, e. g., +AB is the prefix notation for infix addition operation.

(3) **Cambridge Polish Notation:** Polish notation for algebraic expressions in languages in which arity of operators is variable like LISP language.

(4) **Postfix Notation**: Operation is said to be in 'Postfix Notation' if operator is fixed after its operands e.g., AB+ is the postfix notation for infix addition operation. Compiler converts the infix notation of an operation in the source file into its equivalent postfix notation for its evaluation using stack data structure.

(5) **Reverse Polish Prefix Notation**: It is for algebraic expressions which consist of only addition and multiplication operators of fixed arity. It is the Polish Prefix notation of the expression written in Reverse (Backward) order. It is +BA for A + B.

<table>
<tr><th colspan="5">Different Notations of an Algebraic Operation</th></tr>
<tr><th rowspan="2">Infix Notation</th><th colspan="2">Polish Notation</th><th rowspan="2">Postfix Notation</th><th rowspan="2">Reverse Polish Prefix Notation</th></tr>
<tr><th>Polish Prefix Notation</th><th>Cambridge Polish Notation</th></tr>
</table>

Among all these notations, algebraic operations expressed in the Postfix Notation executes fastest. All algebraic operations appearing in any source code are converted into postfix notations by the compiler while translating source code into executable code. Computer associates an unsigned integer value with each built-in operator. No operator gets more than one unsigned integer value. Same unsigned integer value can be associated with multiple operators. Unsigned integer value associated with an operator is called operator's **Precedence Value**. Precedence value of an operator is an estimate of how strongly the operator binds its operands. Lower (Higher) the precedence value, stronger (weaker) the binding and earlier (latter) the evaluation of the operation represented by the operator. Operators are evaluated in the ascending sequence of their precedence values. Operator of lower precedence value is evaluated before the operator of higher precedence value: Precedence value of a term (expression) is the precedence value of its that operator which is evaluated last. Parentheses is treated as an operator which itself does not perform any operation but gives preference to evaluation of the expression enclosed in it. Precedence value of parentheses is less than the minimum precedence value outside the parenthesized expression. Parentheses as an operator gets multiple precedence values whenever there is a nesting of parenthesis expression. Precedence value of inner parentheses is less than the precedence value of the immediate outer parenthesis operator. Zero precedence value is given to entire group of machine instructions which system executes for replacing the name of a variable by its value. Besides precedence values of operators appearing in the source code, computers also associate precedence values with different machine instructions executed by it during runtime for making user's source program executable. Precedence values of different machine instructions decide the sequence of their execution during runtime. The precedence values of different operators and machine instructions do not increase or decrease by one. Range of precedence values of operators and machine instructions varies from language to language. Range of precedence values is more in languages which allow user defined operators than languages which do not allow user defined operators. Precedence values are in range 0-1200 in PROLOG (**PRO**gramming in **LOG**ic) language and in the range 0-300 in ANSI 'C' language. Precedence values of operators alone are sufficient for the evaluation of those expressions in which either no operator repeats and/or no two operators have same precedence value, i.e., expression in which no precedence value repeats. Precedence values alone are not sufficient for the evaluation of those expressions in which either an operator repeats and/or different operators have same precedence value i.e., expression in which precedence value repeats. Such expressions are evaluated using associativity of operators along with their precedence values. Associativity of operators is a property that determines how operators of same precedence value are grouped and evaluated in the absence of any parentheses. Associativity of operator is of three kinds viz '**Left Associativity**', '**Right Associativity**' and '**No Associativity**'. Associativity is another criterion of classifying operators.

(1) Operator of left associativity is called '**Left Associative Operator**'. For a left associative operator, its leftmost appearance in the expression binds its operands more strongly than its other appearances. Addition (+), Subtraction (-), Multiplication (*) and division (/) are left associative operators. The algebraic expression a + b – c is thus treated as ((a + b) + c) by the translator during translation of source code into executable code.

(2) Operator of right associativity is called '**Right Associative Operator**'. For a right associative operator, its rightmost appearance in the expression binds its operands more strongly than its other appearances. Assignment operator is a right associative operator. The algebraic expression a = b = c is thus treated as (a = (b = c)) by the translator while translating source code into executable code.

(3) Operator of no associativity is called '**No Associative Operator**'. No Associative Operator is both left associative and right associative. Generally languages designed for artificial intelligence, like PROLOG and LISP, support no associative operators e.g. 'if' operator of PROLOG symbolically represented as '**:-**' is a no associative operator. Operators of equal precedence value are generally of same associativity e. g., addition and subtraction operators have same precedence value and both are left associative. However, based on his/her computational requirements, a user can overrule the built-in associativity and precedence value of operators by parenthesizing them suitably. Associativity of an operator is also called '**Fixity of Operator**'. Following are the important aspects of evaluation of an algebraic expression by a digital computer.

(1) Infix form is scanned from Left to Right during its conversion to Post fix form.
(2) Post fix form is scanned from Left to Right during its evaluation.
(3) Infix form is scanned from Right to Left during its conversion to Polish Prefix form.
(4) Polish Prefix fix form is scanned from Right to Left to during its evaluation.
(5) Conversion of Infix form to Post fix and Polish Prefix forms is done using data structure Stack.
(6) Evaluation of Postfix and Polish Prefix forms is done using data structure Stack.
(7) Postfix is the fastest execution among all forms.

Infix and corresponding Postfix forms for simple and parenthesised expressions.	
Infix form	**Postfix form**
A * B + C / D – E	A B * C D / + E -
A * (B + C) / D – E	A B C + * D / E -

Infix and corresponding Polish Prefix forms for simple and parenthesised expressions.	
Infix form	**Polish Prefix form**
A * B + C / D – E	- + * A B / C D E
A * (B + C) / D – E	- / * A + B C D E

Computer programming Languages supporting user defined operators, like Fortran-90 and PROLOG, have built-in rules, syntax, semantics and built-in procedures enabling its users to specify symbol, precedence value, associativity and operation of user defined operator. User defined operator is also called '**Derived Operator**'. Arity, precedence value and associativity are the computational attributes of both built-in and derived algebraic operators. Sequence of evaluation of an operator in any algebraic expression is well defined by its precedence value and associativity in computer science while (1) sequence of evaluation of operands of an operator and (2) sequence of evaluation of arguments of a subprogram, are undefined. Postfix form of algebraic notation among infix, POLISH and postfix notations of any algebraic operation is the fastest executing form and has the best computational efficiency whereas infix form is the slowest executing and POLISH form is in between infix and postfix forms. Prefix form is less efficient than postfix form creation of prefix form requires use of two stacks whereas creation post postfix form requires only one stack. Data structure stack works on Last-In-First-Out (LIFO) protocol. Algorithm which converts infix form of an algebraic expression into its postfix form has better space and time complexities than the algorithm which converts infix form to its prefix form. Algorithms of better space and time complexities have better computational efficiency. Space complexity of an algorithm refers to space (memory) requirement of algorithm. Space complexity is good if space requirement is less and it is bad if space requirement is more. Time complexity of an algorithm is good if execution time of algorithm is less and it is bad if execution time requirement is more. **Algebraic operations are taught to humans in their school, college and university levels of education in the infix nation which has least efficient computational efficiency.**

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International Monsoons Project Office (IMPO) at IITM, Pune

Compiled by

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The International Monsoons Project Office (IMPO), hosted by IITM, is a joint effort by WMO and IITM for helping to coordinate monsoon research across the world. Earlier, **IITM was hosting** International CLIVAR Monsoons Project Office (**ICMPO**) during last 5 years, **mainly to coordinate CLIVAR/GEWEX Monsoons panel and its working groups**. Thus, ICMPO was mainly related to two important **core projects**, namely **CLIVAR** (**Cli**mate and Ocean: **Var**iability, Predictability and Change) and **GEWEX** (The **G**lobal **E**nergy and **W**ater **Ex**changes) **of** the World Climate Research Programme (**WCRP**) **of WMO**. ICMPO used to publish six-monthly scientific magazines called "**CLIVAR Exchanges**" in coordination with ICGPO (International CLIVAR Global Project Office), hosted by China. ICGPO and ICMPO were the two nodes of ICPO (International CLIVAR Project Office) in the world. **ICMPO completed its scheduled tenure in this year. Recently, a new agreement was signed between the Secretary-General of the World Meteorological Organization (WMO) and the Director of Indian Institute of Tropical Meteorology (IITM), with the kind approval of the Hon'ble Minister of Earth Sciences, Govt. of India to host an International Monsoons Project Office (IMPO) at IITM Pune India, initially for five years with effect from 30 July 2021, to support monsoon research activities of the World Weather Research Programme (WWRP) and the World Climate Research Programme (WCRP) of WMO. Basically, IMPO will represent an important contribution of India to WMO's monsoon research coordination activities under WWRP and WCRP.** Through dignitaries of the Ministry of Earth Sciences (MoES), WMO (WWRP & WCRP), IITM and IMPO, a **high-level launch of IMPO** has been proposed to be organized sometime towards the end of November or the beginning of December 2021. **Dr. Rupa Kumar Kolli**, Executive Director of IMPO and **Prof. Ravi Shankar Nanjundiah**, Director of IITM contributed significantly for the establishment of IMPO at IITM Pune, with kind support from the Secretary, MoES, Government of India.

In addition to the Executive Director, two senior scientists are being attached to IMPO. At present, **Dr. Susmitha Joseph and Mr. Somnath Mahapatra** are working as Senior Scientists of IMPO to provide necessary supports, in addition to their regular duties in their official position of Scientist-E at IITM Pune. **Dr. Ashwini Kulkarni**, retired Scientist-F & Project Director at IITM Pune, had been working as Senior Scientist with ICMPO/IMPO, before her superannuation.

IMPO functions as a global hub of monsoon research coordination, covering all monsoon regions of the world and spanning weather to climate change time scales. One of the core responsibilities of the IMPO is to **support the activities of the CLIVAR/GEWEX Monsoons Panel and its 3 Working groups (WG)**, namely Asian-Australian Monsoons (**AAM**) WG, American Monsoons (**AMM**) WG and African Monsoons (**AFM)** WG. IMPO also supports cross-panel linkages within the working structure of the WCRP and its core projects as well as WWRP substructures, on monsoon-related matters. A key example in this regard is the Indian Ocean Region Panel (**IORP**) under CLIVAR of WCRP. IMPO also supports WWRP Working Group on Tropical Meteorology Research **(WGTMR).** In addition, IMPO supports the **IWM** (**International Workshop on Monsoons**) **Series of workshops** & the associated activities. The IWM series provide a forum for researchers and forecasters to discuss recent advances and current issues involving monsoons as an example of an earth-system phenomenon covering weather-to-climate time scales affecting large populations around the world. The emphasis is to address monsoon impacts as part of the societal challenges of the WWRP: high-impact weather, water, agriculture, urbanization, and new technologies, in monsoon regions around the world. The outcomes of IWM are sought to transfer new science and technology to National Meteorological and Hydrological Services (**NMHS**) over the relevant monsoon regions. The IWM-7 has two components, an online training workshop in November 2021 and a scientific workshop in spring 2022 (in India during early 2022).

In association with IITM Pune, IMPO will support the organization of forthcoming **Online Training Workshop on "Sub-seasonal to Seasonal (S2S) Prediction of Monsoons",** scheduled during 1 - 12 November 2021, in conjunction with Seventh WMO International Workshop on Monsoons (**IWM-7**). It may be noted that **IWM-7** will be held in **early 2022 in India** and will be jointly organized by the India Meteorological Department (**IMD**), Ministry of Earth Sciences, Government of India and the **WWRP** Working Group on Tropical Meteorology Research (**WGTMR**), in cooperation with the **CLIVAR/ GEWEX Monsoons Panel** of the World Climate Research Programme (**WCRP**).

For organization of the above **Online Training Workshop on S2S Prediction of Monsoons**, IMPO is in constant touch with its International Organizing Committee (**IOC**), co-chaired by **Dr. Àngel Muñoz** of International Research Institute for Climate and Society (**IRI**), **USA** and Member, WCRP Working Group on Sub-seasonal to Interdecadal Prediction (**WGSIP**), and **Dr. Rupa Kumar Kolli** of **IMPO** (International Monsoons Project Office), Indian Institute of Tropical Meteorology (**IITM**), India and Co-Lead, WMO Expert Team on Climate Services Information System Operations (**ET-CSISO**).

The online training workshop will be focused on the sub-seasonal to seasonal (**S2S**) **prediction of monsoons** and will offer short courses to NMHS forecasters. Specific topics will include **S2S predictability sources, Access to the S2S database and tools, Model validation and forecast verification, and Calibration and ensemble techniques.**

Registration process for this online training workshop is already over and more than 80 participants (trainees) from different countries are expected to attend this workshop. **An online pre-workshop orientation course** will be offered to the participants before the main training workshop, during 13-14 October 2021, to introduce and facilitate the data and tools to be compiled by the trainees in advance and to familiarize the trainees with the workshop procedures including the practical sessions.

More information for the above online training workshop is available at the following web page: https://impo.tropmet.res.in/iwm7training.php

In addition to the above activities, IMPO is supporting the organization of the first Southern Asian Climate Research Forum **(SACRF),** scheduled tentatively on 30th November 2021. For this, IMPO personnel are engaging themselves in planning meetings with WCRP Secretariat, and various members & Regional Focal Points **(RFPs)** of SACRF.

Thus, IMPO will serve to produce more visibility of India in the International forum, towards coordination of monsoons research in the world, and associated activities.

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IMSP News: Some recent activities of IMSP

(Compiled by Somnath Mahapatra, Ex-Officio Member, IMSP EC)

IMSP published two online issues of Bulletin of IMSP (**BIMSP**): **April-June 2021** issue, Volume: 20, No. 4-6**, and July-September 2021** issue, Volume: 20, No. 7-9, recently. **Mr. Somnath Mahapatra and Dr. J. R. Kulkarni** contributed significantly for compilation and editing of the above issues of BIMSP and **Mr. Sanjay Sonparote** provided kind support for uploading these issues on **IMSP website** to make these **BIMSP issues** available online at **https://www.imdpune.gov.in/Links/imsp/index.html** On behalf of IMSP, we wish to **thank all authors of the articles published** in the above issues of BIMSP and **Dr. C. Gnanaseelan**, Chairman IMSP for his kind support.

IMSP conducted a Special IMSP Lecture by Prof. Elena Surovyatkina, Group Leader of Monsoon Research at the Potsdam Institute for Climate Impact Research, Germany, being held online on **24th September 2021** (during 05:00 PM - 06:30 PM of India) as a part of Azadi ka Amrit Mahotsav of India. The topic of her lecture was "**Predicting Onset and Withdrawal of Indian Summer Monsoon: Recent Advance and Extension"**. **Dr. R. Krishnan, Dr. C. Gnanaseelan, Dr. K. Madhuchandra Reddy and Mr. S. M. Jamadar** contributed significantly for organization of the above IMSP lecture, in association with IITM Pune. The lecture was attended online by a large number of IMSP members, scientists & researchers.

IMSP communicated with various scientists, inviting **scientific articles for Bulletin of IMSP** (BIMSP), provided **wider publicity for INTROMET-2021 abstract submission & registration process, IMS Award circulars, etc.** and provided necessary support to interested scientists/researchers for **new Life memberships** of IMS. **New Life members of IMS** (from IMSP side) include **Dr. P. Vijay, Ms. Anjani Kumari, Mr. Yang Lian, Ms. Darshana Patekar, etc.** Also, **Dr. Satyaban B. Ratna, Dr. C. T. Sabeerali and others** returned Pune to enhance the strength of IMSP.

There is an **IMSP WhatsApp group**, where the members make lot of scientific discussions, especially related to current weather conditions, climate change issues, extreme & disastrous events, etc. Also, the senior members explain atmospheric processes and various events in simple manner, thus popularising the science to the society and disseminating the knowledge in effective manner.

Several life members of IMSP have made very important scientific contributions in recent past, e. g., contributing for **IPCC AR-6 Report,** publishing of **books on monsoon variability,** establishing of **weather instruments in remote places**, etc. **They are requested kindly to send some popular articles for BIMSP related to their recent works**, so that new scientific developments can be disseminated to the society in simple language (one of the important objectives of our society).

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Jan Lukasiewicz
Polish Logician and Philosopher

IMSP

INDIAN METEOROLOGICAL SOCIETY,
PUNE CHAPTER
(A Scientific Society registered under Govt. of India, New Delhi)

WEBSITE: http://www.imdpune.gov.in/imsp