



ChemTech

International Journal of ChemTech Research

CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.11 No.01, pp 300-307, 2018

The Need for Motivation and Awareness of Green Chemistry Synthetic routes among Chemistry Postgraduates in India

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Abstract : The multidisciplinary nature of Synthetic Green Chemistry is recognized worldwide as a route to the development of chemical products and process with lower environmental impact. In recent years there is greater societal expectation that chemists and chemical engineers should produce greener and more sustainable chemical processes and it is likely that this trend will continue to grow over the next few decades. Practicing of Green Chemistry in India is necessity rather than an option. In developed countries especially in USA & UK several Institutions & Universities are offering the degree course in Green Chemistry. Indian Universities are yet to start. Few Indian universities offer Green Chemistry as optional paper including Bangalore University; students are not opting for Green Chemistry. To promote uptake of green and sustainable methodologies amongst the chemical and chemical-using industries requires the exemplification of green chemistry in education and training material to influence, motivate and inspire the next generation of scientists.

Herein, we examine the awareness of importance of Synthetic Green Chemistry monitored through a questionnaire among the Post Graduate students of Chemistry from Bangalore City. Some Good colleges of Bangalore were selected under five Categories. The results were statically analyzed by Chi square method and a Hypothesis was tested.

Key Words : Synthetic Green Chemistry; Environmental Education; Sustainability. Environmental Protection Agency, Green Products, Green House Gases GHG , Paris Summit of Dec.2015 on Climate Change. Inter –governmental panel on Climate Change (IPCC), Renewable Technologies, Green and Clean Technology

Introduction:

To create a cleaner, safer, and healthier energy future, it's time to choose renewables first. Green Chemistry has undoubtedly been one of the most noteworthy advancements in the chemical sciences of late and is recognized worldwide to describe the development of more sustainable chemical products and processes[1]

The multidisciplinary nature of green chemistry is one of the keys to its success. The combination of chemistry, chemical engineering and biology are a powerful tool for meeting the challenges for developing cleaner processes. By rethinking chemical design from the ground up, chemists are developing new ways to manufacture products that fuel the economy and lifestyles, without the damages to the environment that have become all too evident in recent years. Thus, green chemistry has emerged as a discipline that permeates all aspects of synthetic chemistry[2].

To promote uptake of green and sustainable methodologies amongst the chemical and chemical-using industries requires the exemplification of green chemistry in education and training material to influence, motivate and inspire the next generation of scientists [3]

The products of the chemical industry are ubiquitous in modern society and have greatly improved the quality of our lives; however manufacturing these products in both an environmentally compatible and economically viable way is of critical importance [4-5]. Solutions will only be found through collaboration between a multidisciplinary community of chemists, biologists, engineers, economists and legislators. Hence the need for graduates with the requisite skills, knowledge and experience is growing.

Green Chemistry is emerging in academic institutions all over the World particularly in developed countries. In India the Green Chemistry Net work GCN in New Delhi is participating in projects and Conferences conducted by ACS and IGS internationally. But no Indian university has not yet started UG or PG degree course in Green Chemistry. However the importance of green chemistry has been reported by few Indians [6-8].The research and development and the science and technology agencies that are responsible for the funding of scientific activities in India must encourage and give preference to the development of greener science and technology. The GCCE at the University of York (UK) is a world leading research centre which aims to promote the development and implementation of green and sustainable chemistry and related technologies into new products and processes [9]

A key Global Challenge in the 21st Century is how to address the Climate Change and reduce Green House Gas (GHE) emissions. Government regulatory bodies and consumer pressure groups have aggressively lobbied for Business to adopt Green practices.

The Green Chemistry Commitment (GCC) is currently the only nationwide program specifically designed to encourage, empower, and celebrate entire departments of chemistry that transform their curriculum through green chemistry. The time calls for the implement of Green chemistry at postgraduate science courses So as to make students aware of environment and issues and efforts going on Worldwide to address these issues [10-11].Co-operation of Green chemistry in curriculum in some foreign Universities has Fueled a fundamentally new approach of teaching chemistry [12]. To practice and increase the research in Green chemistry field we need to publish the need, Efforts And practice of Green chemistry. Thus the awareness of Green chemistry among post graduate Level is highly essential and by introducing chemistry at PG level the Government Can build a strong Foundation towards Green chemistry in India.

Materials and Method:

To assess the awareness in Green Synthesis and Green Chemistry , few good colleges of Bangalore with good Grades from NAAC (National Assessment & Accreditation Committee) were selected under the following categories:

(1) Deemed Universities. (2) Autonomous Colleges (3) Government Colleges (4) Private Unaided Colleges

In order to obtain full and relevant information from the students from the above mentioned Institutions a Questionnaire was prepared by the investigator. The Questionnaire consisted of 35 questions and being a multiple choice had four for each question. The students were provided with OMR sheets to circle their correct answers. Before giving the questionnaire to the students, A brief presentation about Green Synthesis and chemistry for sustainability was made by the Investigator. The Questionnaire was designed in such a way that it covered all the fundamentals And Basic Questions needed for the awareness of Green synthesis and Chemistry.

Sample Size: The number of students from each institution is shown in **Table 1**.

Table-1SAMPLE SIZE: The number of students from each institution

SL No	Name of the University/Institutions	Type/Affiliation	Student's Course	No of Students
1	INDIAN INSITUTE OF SCIENCE, IISC;	Public University	Ph.D's Chemistry	61
2	BANGALORE UNIVERSITY , BU	Public State UNIV.	M.Sc. Chemistry	25
3	JAIN UNIVERSITY, JNU	Deemed Private	M.Sc. Chemistry	15
4	DyanandaSagar Group of Institutions	Autonomous/BU	M.Sc. Chemistry	09
5	St.Joesph 's Colllege	Autonomous /BU	M.Sc. Chemistry	11
6	M.S.Ramaiya Group of Institutions	Autonomous/BU	M.Sc. Chemistry	09
7	NMKRV Women's College	Autonomous/BU	M.Sc. Chemistry	11
8	Maharani Amani Women's College	Autonomous/B U	M.Sc. Chemistry	06
9	KLE Niglingappa College	Autonomous/BU	M.Sc. Chemistry	10
10	Government Science College	Autonomous/BU	M.Sc. Chemistry	12
11	VV Purum College	Autonomous/BU	M.Sc. Chemistry	09
12	T.John Group of Institutions	Pvt. Un Aided/BU	M.Sc. Chemistry	07
13	Oxford Group of Institutions	Pvt. Un Aided/BU	M.Sc. Chemistry	73
14	AMC Group of Institutions	Pvt.Un Aided /BU	M.Sc. Chemistry	04
15	Brindavan Group of Institutions	Pvt.Un Aided /BU	M.Sc. Chemistry	06
Total Number of Post Graduate Chemistry Students 268				

Experimental Investigation:

The Analyses of the data of awareness Green Synthesis and Green Chemistry collected from various institutions was carried out by considering the objectives of the study by suitable statistical method. The Green Synthesis and Green chemistry awareness results obtained from the students of various Institutions were assessed depending upon the number of correct answers from the OMR answer sheets of students. The results are shown in Table-2

Table-2 Awareness Levels among Students

Well aware	Fairly aware	Partly aware	Poorly aware
78	93	76	21

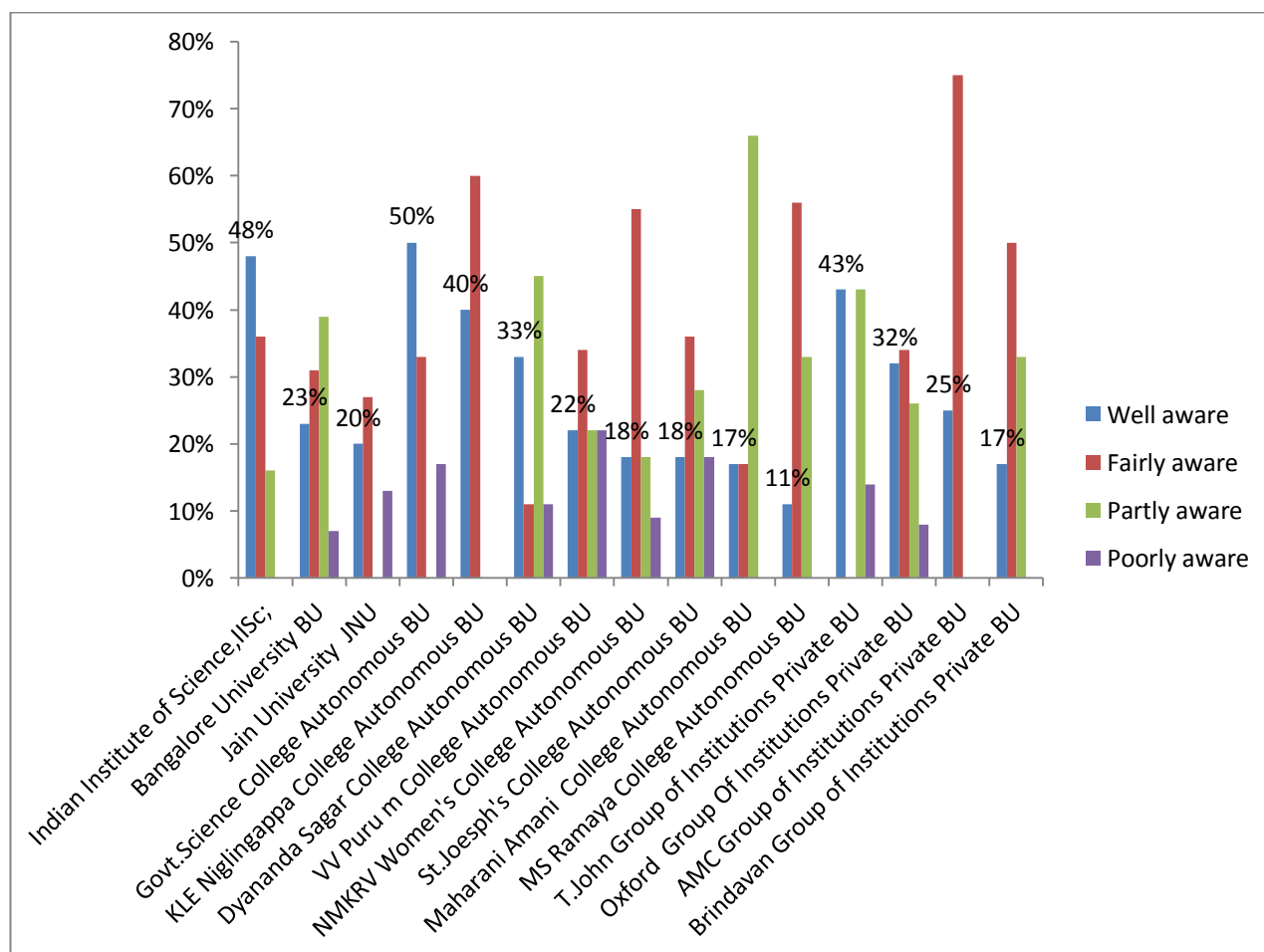
It can be observed from the above Table-2 that the results are categorized under four levels of awareness as follows:

1. **Well aware level:** Students who obtained percentage between 100-80% by getting 35-28 correct answers from the questionnaire.
2. **Fairly aware level:** Students who obtained percentage between 79-60% by getting 27-21 correct answers correct from the questionnaire
3. **Partly aware level :** Students who obtained percentage between 59-33% by getting 20-12 correct answers from the questionnaire
4. **Poorly aware level** Students who obtained percentage between 32-20% by getting 11-7 correct answers from the questionnaire.

Percentage of Awareness levels of various Institutions is tabulated in Table-3 .

Table-3- Green Chemistry Synthetic routes Awareness Results of PG Students of Various Institutions

SL No	University/Institutions	Well aware	Fairly aware	Partly aware	Poorly aware
1	INDIAN INSTITUTE OF SCIENCE, Public University,IISc;	48 %	36 %	16 %	0 0 %
2	BANGALORE UNIVERSITY Public State University,BU	23 %	31%	39 %	7.0%
3	JAIN UNIVERSITY, Deemed Private University, JNU	20 %	27 %	00 %	13%
4	Government Science College Autonomus,BU	50 %	33 %	00 %	17%
5	KLE NiglingappaCollege,Autonomus,BU	40 %	60 %	00 %	00 %
6	DayanandaSagar College, Autonomus,BU	33 %	11 %	45%	11 %
7	VV Purum College, Autonomus, BU	22 %	34 %	22 %	22 %
8	NMKRV Women's College, Autonomus,BU	18 %	55 %	18 %	09 %
9	St.Joesph's College, Autonomus,BU	18 %	36 %	28 %	18 %
10	Maharani Amani College, Autonomus,BU	17 %	17 %	66 %	00 %
11	MS RAMYA College, Autonomus, BU	11 %	56 %	33 %	00 %
12	T.John Group of Institutions,PRIVATE,BU	43 %	0.0 %	43 %	14 %
13	Oxford Group of Institutions ,Private ,BU	17 %	50 %	33 %	00 %
14	AMC Group of Institutions,Private,BU	25%	75%	00%	00 %
15	Brindavan Group of Instutions,PRIVATE, BU	17%	50%	33%	00%

**FIG-1- Graphical representation of Green Chemistry Synthetic routes Awareness Results of PG Students of various Institutions**

It can be observed from Table-3 that the well aware level percentage is highest with Govt. Science autonomous College which is 50% ,next highest is 48% with Public University IISc; the Pvt.Unaided T.John College shows 43% in Well aware level. From Table-3 the percentage of various awareness levels of different institutions are clearly revealed. From Fig-1 Graphical representation of percentage awareness of different levels of Institutions is seen clearly.

In order to understand the awareness levels among the institutions of different categories the percentage of Awareness levels were calculated under three categories namely Public university, Autonomous and Private Unaided Institutions and are tabulated in table-4 and presented graphically in fig-2

Table-4- Percentage of Awareness levels of various categories

Type of Institution	Awareness Level Percentage				Total
	Well aware	Fairly aware	Partly aware	Poorly aware	
Public University	29%	32%	33%	6%	101
Autonomous	27%	39%	24%	10%	77
Private Unaided	31%	34%	27%	8%	90
Total	78	93	76	21	268

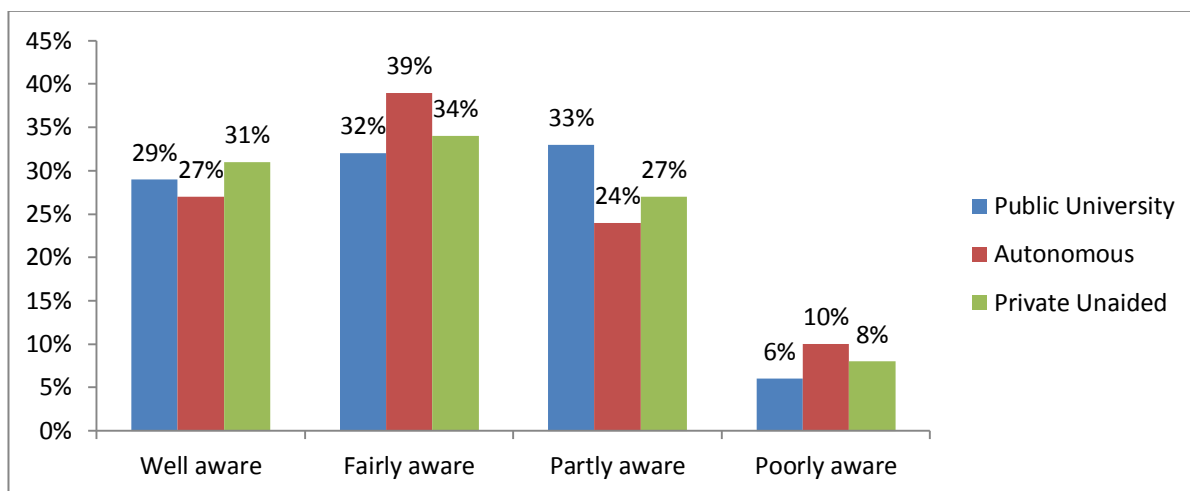


FIG-2-Graphical representation of Overall % Awareness levels of various categories

It is clearly observed from Table-4 and Fig-2 that the well aware level percentage lies between 31-27%. The category of Private Unaided institution has 31%, Public university and Autonomous category reveals 29% and 27% respectively. Fairly aware level percentage lies between 39-32% Autonomous Institution Category showing 39% ,Private Unaided Institution category and Public University showing 34% and 32% respectively. Partly aware level percentage ranges between 33-27%,Public University category shows 33% ,Private Unaided Institution category and Autonomous category show 27% and 24% respectively. Poorly aware level percentage is small compared to the other above mentioned levels and the range is seen between 10-6%.Autonomous Institution category shows 10% whereas the Private Unaided Institution and Public University shows 8% and 6% respectively.

Further the Overall percentage Awareness levels among 268 students has been calculated and is tabulated in Table-6 follows:

Table-5-Overall % Awareness levels among 268 Students Sample

Well aware	Fairly aware	Partly aware	Poorly aware
29%	35%	28%	8%

The Overall percentage Awareness levels of total 268 Student sample from table -5 reveals that the well aware percentage is 29% and fairly aware level is 35%. The partly aware level and Poorly aware percentage being 28% and 8% respectively. This indicates that students have fairly satisfactory awareness of Green Synthesis and Green Chemistry as the poorly awareness level percentage is just 8%. The Pi chart clearly reveals the Overall Percentage Awareness levels Among 268 Post graduate students sample which has been investigated in the present study. The Pi chart is shown in Fig-3 as follows:

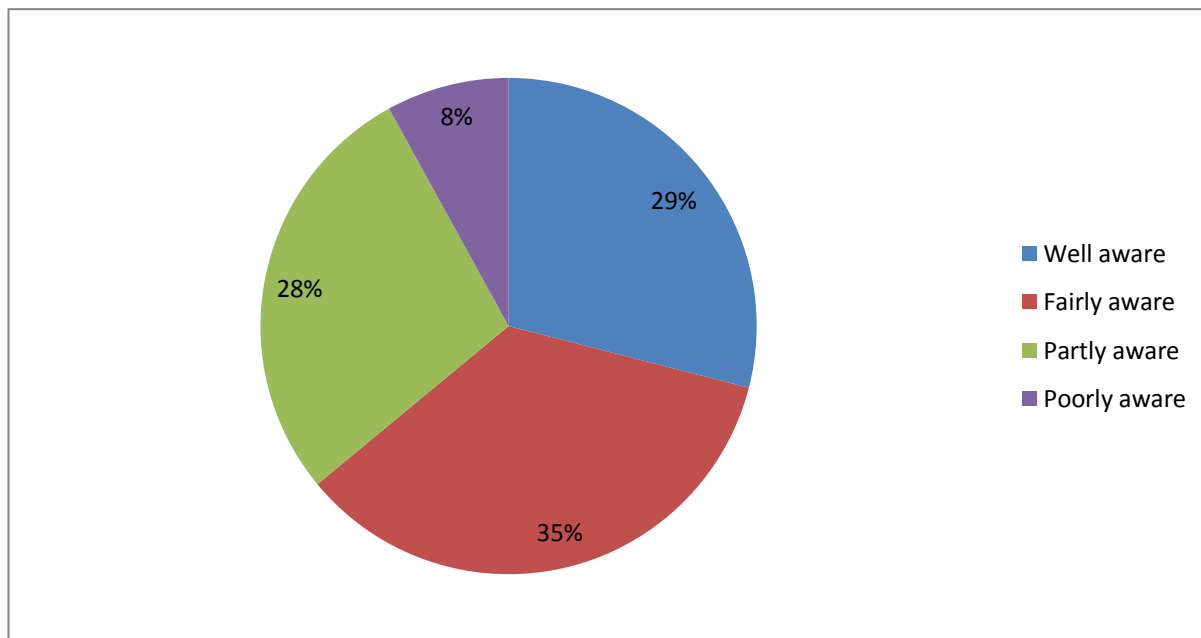


FIG-3- Graphical representation of Overall % Awareness levels among 268 Students Sample

Results and Discussion:

Statistical computations by Chi-Square Test have been used for the results analysis. The Chi-Square (X^2) measures the difference between observed (O) and expected (E) frequencies of nominal variables in which subjects are grouped in categories or Cells. The Chi-Square uses the formula as follows:

$$X^2 = \sum (O-E)^2 / E$$

Where the letter O represents the observed frequency, the actual count in a given cell. The letter E represents the Expected frequency, a theoretical count for that cell. Its value must be computed. The more O differs from E, the larger X^2 is. When X^2 exceeds the appropriate critical value, it is declared significant.

The chi-square Tests can be used on actual numbers and not on percentages.

The results of number of students in different awareness levels of various institutions categories in present study are calculated and are shown in Table-6 as follows:

Table-6 Number of students in awareness levels under 3 categories

Type of Institution	Awareness Levels				Total
	Well aware	Fairly aware	Partly aware	Poorly aware	
Public University	29	32	34	6	101
Autonomous	21	30	18	8	77
Private Unaided	28	31	24	7	90
Total	78	93	76	21	268

The above table shows the **number of students** in various awareness levels of different institutions categories.

The data tabulated in the above Table-6 was subjected for carrying out the **Chi-Square Test** for testing the Hypothesis.

Hypothesis: There is no association between levels of awareness and type of Institutions. The computation of X^2 test statics data obtained for testing the for Hypothesis are tabulated in Table-8 as follows:

Table 7: Association of type of institution and level of awareness for Synthetic Green Chemistry

Type of Institution	Awareness Levels				Total
	Well aware	Fairly aware	Partly aware	Poorly aware	
Public University	29 (29.4)	32 (35.0)	34 (28.6)	6 (7.9)	101
Autonomous	21 (22.4)	30 (26.7)	18 (21.8)	8 (6)	77
Private Unaided	28 (26.2)	31 (31.2)	24 (25.5)	7 (7.1)	90
Total	78	93	76	21	268

Figures in paranthesis are expected counts/frequencies

Chi-Square Tests (Table-7)

Pearson Chi-Square Value = 3.759, Asymptotic significance = 0.709

Intepretation:

As observed from table-7, the chi-square value is 3.759 and a p-value of 0.709 ($0.709 > 0.05$) indicating that the null hypothesis of no association between the type of institution and level awareness is accepted statistically at 5% level of significance. In other words, there is no evidence (statistically) that there is an association between type of institution and level of Awareness for Green Synthesis and Chemistry subject.

Conclusions

1. The overall results of Green Chemistry Synthetic routes awareness levels among post graduate students of Chemistry indicates that the awareness results does not depend on type of Institution.
2. Satisfactory overall percentage of awareness is seen in Well aware, Fairly aware and Partly aware levels. Poorly aware level being just 8%.Which indicate that if students are motivated and inspired they will opt for optional Synthetic green chemistry in their course.
3. Government Institutions and Public universities should start Synthetic green chemistry course at post graduate level as they get funded by Government. It is also possible for the private and autonomous institutions to start the Synthetic green chemistry course as they attract and admit NRI students.
4. Practicing Synthetic green Chemistry in India is necessity rather than an option. The R&D Science and Technology agencies that are responsible for the funding of scientific activities In the country must encourage and give preference to the development of greener sciences And Technology and therefore help in sustainability to a great extent and thus contribute for Achieving a sustainable tomorrow.
5. Synthetic Green Chemistry can play a role to combat present **environment threats** and **Climate Change** by reducing Green House Gas (GHE) emissions which is a key Global Challenge in the 21st Century.

Acknowledgement

I thank Shri.D.T. Srinivas, Secretary & Mrs.P oornima K.Srinivas, Treasurer & C.E.O, S.E.A.E.Tfor their cooperation. My thanks to all the Principals & HOD's of various institutions for permitting to carry out the questionnaire test. I am thankful to Jayasimah of Sigma Tabs. I will always remain grateful to late Prof.V.K.Jain,Prof.C.L.Khetrapal and eminent Professor and Scientist Bharat Ratana C.N.R.Rao for their

encouragement during my Ph.D Interdisciplinary outstanding work which I carried out in Aerospace Dept IISc; several decades ago. Further I could not do much as interdisciplinary work requires extra cooperation, good opportunities with moral and financial support& one has to be fortunate. Hope in future something works out. Finally Iam thankful to my late Parents and my Religious Father Dr. Syedna Aali QadarMuffadal Saifuddin(t.u.s) Chancellor of AMU for their blessings.

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