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Assessment Of Green Chemistry Knowledge, Awareness And Attitude Among The College Students Of Rajasthan

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Abstract: The environment faces many threats that harm human health. To tackle these issues, Anastas and Warner introduced Green Chemistry. This concept helps people find safer ways to use and dispose of chemicals. This study investigates the level of green chemistry knowledge, awareness, and attitudes among college students of Rajasthan. It also explores the relationships between these constructs. Using a survey design, data were collected from 305 college students in Udaipur and Dungarpur districts of Rajasthan state through a 45-question questionnaire, consisting of 15 questions (right/wrong type) on green chemistry knowledge and 30 Likert-scale questions on awareness and attitudes. Descriptive analysis revealed high levels of green chemistry knowledge and attitudes, and very high levels of awareness. Pearson correlation analysis showed small correlations between knowledge, awareness, and attitudes. Multivariate Analysis of Variance (MANOVA) indicated no significant differences between urban and rural students regarding their green chemistry knowledge, awareness, and attitudes. The multiple-choice questions on green chemistry knowledge were converted into a new instrument to further analyze university students' knowledge levels, enabling a deeper study of green chemistry knowledge, awareness, and attitudes.

Keywords: **Green chemistry, Knowledge, Awareness, Attitude, College students**

I. INTRODUCTION

The environment faces numerous threats, including the greenhouse effect, global warming, and soil erosion, all of which have detrimental impacts on human health. Many of these issues stem from human activities that exploit the environment without adequate care. For example, disposing of mercury waste in the ocean leads to mercury dissolving in water, penetrating the cells of aquatic life, and bio-accumulating through the food chain. When humans consume contaminated fish, the mercury content can have adverse health effects. Similarly, the use of hazardous chemicals poses significant risks to humans.

To address these concerns, Anastas and Warner (1998) introduced the concept of Green Chemistry, which aims to help humans identify safer ways to use and dispose of chemicals. This involves replacing dangerous chemicals with safer alternatives and conducting experiments with more environmentally friendly substances (Andraos and Matlack, 2022).

College students, who often have the autonomy to make their own choices regarding transportation and waste disposal, need a thorough understanding of green chemistry. This understanding ensures their actions do not harm the environment. It is crucial to investigate their level of knowledge, awareness, and how these aspects relate to their daily lifestyles and attitudes.

Green chemistry awareness is vital due to the ongoing water, soil, and air pollution. College students, who will become future leaders and policymakers, must care about these issues and implement green chemistry attitudes for environmental preservation (Ghosh, 2021). Urban-dwelling college students, in particular, are more likely to use vehicles and engage in waste disposal, making green chemistry awareness essential to

prevent urban environmental problems.

Despite its importance, few studies have gauged the levels of green chemistry awareness, knowledge, and attitude among college students. Most research has focused on general environmental knowledge, awareness, and attitudes (Arshad et al., 2021). However, Ghazali et al., (2022) conducted a study to investigate the level of green chemistry knowledge, awareness, and practices among university students of Kuala Lumpur and Tanjung Malim. Therefore, studying green chemistry awareness and attitude among college students is highly needed. Such study can help students understand and address environmental problems more effectively, contributing to environmental preservation and conservation.

II. REVIEW OF LITERATURE

Qablan and Al-Qaderi (2009) identified modest attitudes and practices towards sustainable development education among environmental science faculty members, proposing training on sustainable development education pedagogy. Karpudewan et al. (2009) found that prospective students exhibit high awareness and motivation towards pro-environmental actions, reflecting tangible changes in environmental values. In a study of 115 student teachers of high school, Esa (2010) showed that teachers have positive environmental attitudes; few contribute to good environmental attitudes, although they frequently recycle materials like cans and paper. In a study Ogunyemi and Ifegbesan (2011) found that high local but low global environmental awareness and knowledge in prospective teachers.

Finale and Massey (2012) found that prospective teachers at two Spanish universities had low environmental knowledge but positive attitudes and simple pro-environmental actions. Manchanayakage (2013) conducted a study to integrate green chemistry into teaching for pure science and social science students. By using science and art students as samples, he introduced green chemistry through classes and labs. The study found that after the course implementation, students' knowledge of green chemistry was significantly positive and encouraging. Burmeister and Eilks (2013) explored the future knowledge of chemistry teachers in Germany concerning Education for Sustainable Development (ESD). Their study revealed that only a few teachers could provide clear answers or support their ESD concepts with appropriate theory. Similarly, Mahat et al. (2014) investigated the relationship between parents' awareness, knowledge, and behavior with students regarding Education for Sustainable Development (ESD). They found that parental knowledge about ESD was higher in urban areas compared to rural areas. Olsson et al. (2016) found that the implementation of ESD in the Swedish curriculum had little effect on students' attitudes.

In a study Żuk and Żuk (2018) found higher environmental awareness among humanitarian students. They argued that environmental awareness is more conducive to humanitarian studies. Mohamad et al. (2018) focused on campus sustainability, and found that high student awareness contributed to preserving campus lakes. However, they noted that this awareness was short-lived, suggesting the need for long-term strategies. Abiolu (2018) found that Nigerian youths have high environmental knowledge but low pro-environmental measures and moderate attitudes, suggesting the need for environmental education through appropriate media. Sidiropoulos (2018) showed that students' knowledge of Sustainability Education (SE) positively impacted the formation of Nature in Self (INS) or inclusive feelings in nature, resulting in a greater love for nature. Fang et al. (2018) supported Sidiropoulos' findings, indicating that environmental knowledge clarifies university students' environmental attitudes.

A study in USA suggested that incorporating environmental education early in university can enhance the quality of environmental education for future students (Yates et al., 2018). They advocated for training to increase environmental knowledge among teachers. Płotka-Wasylka et al. (2018) emphasized the necessity for students to learn about green chemistry for environmental preservation and suggested curriculum changes to address the lack of green chemistry awareness.

Mohiuddin et al. (2018) studied students' environmental knowledge and its impact on selecting green technology vehicles. Their research indicated that environmental knowledge significantly influenced students' preference for green vehicles, promoting environmental sustainability. Kanapathy et al. (2018) discovered that while basic knowledge of sustainable development was relatively high among students, it did not significantly influence their behaviors and attitudes towards sustainable development. Nawi and Er (2018) studied campus sustainability among students and staff, finding high awareness but moderate willingness to attitude sustainability. This contrasts with Veisi et al. (2018), who found high environmental sensitivity and attitudes, but only moderate knowledge among students, suggesting the need for enhanced environmental education. Jayaraman et al. (2019) examined university students' knowledge about the environmental effects of laptop materials. They found that students aware of computer components

understood the dangers of improper disposal. Chen et al. (2020) recommended integrating green chemistry learning with environmental studies to improve students' environmental attitudes and awareness.

In a study of university students of Kuala Lumpur and Tanjung Malim, Ghazali et al., (2022) found that the level of green chemistry knowledge and practices among university students is high, while the level of green chemistry awareness is very high. They also found that there is no significant difference between education students and non-education students in their overall green chemistry knowledge, awareness and practices.

This study aims to determine the levels of green chemistry knowledge, awareness, and attitudes among college students. Additionally, it seeks to analyze the correlations between these three constructs. Finally, the research investigates the differences in green chemistry knowledge, awareness, and attitudes between students from urban and rural backgrounds.

III. METHODOLOGY

Research Design

This study is a quantitative study that used surveys as the research design. The main tool was a questionnaire, designed to measure students' knowledge, awareness, and attitude of green chemistry in their daily lives. The study had two phases: the first phase involved creating the questionnaire and testing its validity and reliability through pilot studies, and the second phase was the actual survey. Details about the questionnaire are provided in the study instrument section. The survey was conducted on 305 science students from both urban and rural areas, studying in various colleges in Udaipur and Dungarpur districts of Rajasthan.

Respondent's Characteristics

A total of 305 samples were collected using a stratified random sampling method. Out of these, 181 students (59.3%) were from urban areas, and 124 (40.7%) were from rural backgrounds. Additionally, 201 (65.9%) were male, and 104 (34.1%) were female. Furthermore, 236 (77.4%) were undergraduate students, & 69 (22.6%) were postgraduate students. The data is shown in Table 1.

Table1. Sample Distribution According to Characteristics and Course Type

Characteristics	Rural	Urban	Total	Percentage (%)
Gender				
Male	94	107	201	65.9
Female	30	74	104	34.1
Course				
Undergraduate	98	138	236	77.4
Postgraduate	26	43	69	22.6

Instrument

The tool used in this study is a set of questionnaires with two parts. The first part collects demographic information about the respondents. The second part has three main sections with a total of 45 questions. The first section tests the respondents' knowledge of green chemistry with 15 objective questions covering various principles of green chemistry. The reliability of this section is tested using KR_{20}, with a value of 0.782. KR_{20} was chosen because these questions have only right or wrong answers. The second and third sections assess the students' awareness and attitude of green chemistry, each with 15 questions using a 5-point Likert scale. The validity of these sections is confirmed through face and content validity using the Approval Percentage (PA) between the appointed experts. Their reliability was tested using Cronbach's Alpha, with values of 0.803 for green chemistry awareness and 0.798 for green chemistry attitude, based on a 30-sample pilot study.

Data Analysis

The data from the questionnaires were analyzed using SPSS (Statistical Package for Social Sciences). The mean and standard deviation for each construct were calculated. A Pearson correlation test was used to find correlations, and a one-way Multivariate Analysis of Variance (MANOVA) was conducted to determine differences between urban and rural students.

IV. RESULTS AND DISCUSSION

Analysis of Green Chemistry Knowledge, Awareness and Attitude Level

The analysis of the mean and standard deviation for each construct has been conducted. The data are presented in terms of standard mean and deviation to evaluate the respondents' levels of green chemistry knowledge, awareness, and attitude. For the knowledge construct, multiple-choice objective questions were administered, while for the green chemistry awareness and attitude constructs, a 5-point Likert scale questionnaire was used. The respondents' responses to the knowledge, awareness, and green chemistry constructs are presented as percentages. The mean and standard deviations for all constructs are as follows: green chemistry knowledge (mean = 66.33, SD = 13.24), green chemistry awareness (mean = 81.91, SD = 10.36), and green chemistry attitude (mean = 77.98, SD = 10.04).

According to Che Ahmad et al. (2016), the responses of respondents can be categorized as Very Low, Low, Medium, High, and Very High, based on the Likert scale. Therefore, in accordance with this categorization, the present study classifies the level of green chemistry knowledge and attitude among college students as high, while the level of green chemistry awareness is classified as very high. The detailed data are shown in Table 2 below.

Table2. Mean and standard deviation for green chemistry knowledge, awareness and attitude construct.

Construct	**Mean**	**Standard Deviation**	**Interpretation** (CheAhmad et al., 2016)
Knowledge	67.47	13.68	High
Awareness	83.11	10.44	Very High
Attitude	72.32	10.02	High

The findings of this study align with those of Ghazali et al. (2022), who reported high levels of green chemistry knowledge, awareness, and practice among university students in Malaysia. Similarly, Cheam and Ong (2018) observed elevated environmental behavior among undergraduate students, and Veisi et al. (2019) found comparable results. Furthermore, Cheam and Ong (2018) noted that the level of awareness regarding the importance of environmental preservation among undergraduate students was very high. This outcome is also consistent with the study by Fang et al. (2018), which demonstrated a similarly high level of environmental awareness among undergraduate students.

Correlation Analysis between Variables

An analysis of the correlation between knowledge, awareness, and attitude towards green chemistry was conducted. Since the data meets the assumptions for parametric correlation analysis—normality at p = 0.05 and independence of data—a Pearson (r) correlation analysis was performed. The data obtained are summarized in the following table:

Table 3. Pearson Correlation Coefficient between Constructs

Construct		**Knowledge**	**Awareness**	**Attitude**
Knowledge	Correlation Coeff.	1.000	0.078	0.017
	Sig.(2-tailed)	.	0.154	0.788
	N		305	305
Awareness	Correlation Coeff.		1.000	0.215**
	Sig.(2-tailed)		.	0.000
	N		305	305

**Correlations are significant at 0.01 level (2-tailed)

As shown in Table 3, the relationships between Green Chemistry Knowledge, Green Chemistry Awareness, and Green Chemistry Attitude constructs were investigated using the Pearson Product-Moment Correlation Coefficient. An initial analysis confirmed that there were no violations of the assumptions of normality, linearity, and homoscedasticity.

- There is a small and positive correlation between the knowledge and awareness constructs, r = 0.078, p = 0.154, indicating that higher levels of green chemistry knowledge are associated with higher levels of green chemistry awareness.
- There is a very small and positive correlation between the knowledge and attitude constructs, r = 0.017, p = 0.788, suggesting that higher levels of green chemistry knowledge are slightly associated with higher levels of green chemistry attitude.
- There is a small but significant positive correlation between the awareness and attitude constructs, r

= 0.215, p = 0.000, indicating that higher levels of green chemistry awareness are associated with higher levels of green chemistry attitude.

These findings align with those of Cheam and Ong (2018), who found a low and positive correlation (r = 0.26) between environmental awareness and environmental behaviors. Similarly, Veisi et al. (2018) reported a low and positive correlation between environmental knowledge, sensitivity, and attitude.

Comparison of Green Chemistry Knowledge, Awareness and Attitude Level

A MANOVA analysis was conducted to examine the differences in green chemistry knowledge, awareness, and attitudes between urban and rural students. Initially, homogeneity tests were performed to ensure that the data met the assumptions required for MANOVA. Levene's test indicated non-significant results for green chemistry knowledge (p = 0.608), awareness (p = 0.072), and attitudes (p = 0.778), with all p-values greater than 0.05, confirming the homogeneity of variance for all constructs.

The results of Pillai's Trace multivariate test revealed no significant effect of the type of background (urban versus rural) on the three dependent variables. Consequently, the null hypothesis was accepted, indicating that the type of background does not influence green chemistry knowledge, awareness, or attitudes among college students in the Udaipur and Dungarpur districts of Rajasthan, India. Further MANOVA analysis of all independent variables confirmed that there is no significant difference between the urban and rural categories regarding these constructs.

V. CONCLUSION

The study aimed to investigate the levels of green chemistry knowledge, awareness, and attitudes among college students in Rajasthan, and to explore the relationships between these constructs. Data were collected from 305 students through a questionnaire, and analysis revealed high levels of green chemistry knowledge and attitudes, and very high levels of awareness. Correlation analysis showed small, positive correlations between knowledge, awareness, and attitudes, while MANOVA analysis indicated no significant differences in these constructs between urban and rural students. The findings align with previous studies, highlighting the importance of green chemistry education for fostering environmental awareness and attitudes among college students.

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