

Original Research Article

Evaluation Of Indoor Air Quality In Hospitals: With Respect To Green Building Rating Systems

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ABSTRACT:-

The World Health Organization tightened the various indoor air quality parameters to improve the quality of the air globally during COVID-19. In light of this, research (Pollution and Health: a progress update, 2022) made public in India in 2022 shows that air pollution is a major problem worldwide, with a projected 66.7 lac people dying as a result. Similar issues are present in developing countries like India, where 16.7 million fatalities were expected in 2019. According to the study (Air Quality Life Index : India Fact Sheet, 2022) , air pollution shortens Indians' life expectancy by an average of 5 years.

It is crucial to check that these new standards after Covid are compatible with the Green Building Rating Systems. The study is also based on in-depth discussions with doctors, administrators, green building designers, and building tenants, as well as surveys using questionnaires and interviews. The existing Green Rating Systems were found to require revision, with the weighting of the elements linked to air quality requiring strengthening with the installation of appropriate air quality monitoring of different contaminants. The study's main objective is to examine the air quality parameters, their weightings, and the monitoring tools. The study was focused on the evaluation of Green Rated healthcare buildings in India based on different Air Quality parameters. The overall evaluation of the air quality is found to be very critical and, in the areas, where extreme care and precautions are required with respect to cleanliness and hygiene like the Intensive care unit and Operation Theatre the values of the air pollutants like Formaldehyde, Volatile Organic Compound, Carbon Monoxide and Carbon Di Oxide are indicating serious problems.

Keywords:- Indoor Air Quality, Green Rating Systems,

INTRODUCTION:-

The Report (Pollution and Health: a progress update, 2022) shows that Air pollution is a serious threat to human life and the world population is facing serious problems related to it. Air pollution alone contributes to 66.7 lakh death globally. In India also air pollution started showing its effects. In 2019, there are 16.7 lakh death alone because of air pollution which is around 17.8% of the overall deaths in the country. This was the highest number of deaths in any country through air pollution. 16.7 lakh death caused by PM_{2.5} and another 6.1 death by lakh by household air pollution. The World Health Organization WHO has tightened its health-based global air quality guidelines.

According to a report (Air Quality Life Index : India Fact Sheet, 2022) it is predicted if the guidelines issued by WHO for air quality are not followed in true spirits then the average Indian is set to lose five years of life expectancy. This report claims that India is the second most polluted country after Bangladesh. In India, Delhi is considered the most polluted mega city in the world with PM_{2.5} levels exceeding 107.6 micrograms per cubic metre which is more than 21 times the

WHO guidelines and set to lose 10 years of life expectancy. Globally air pollution is responsible for reducing life expectancy to 2.2 years.

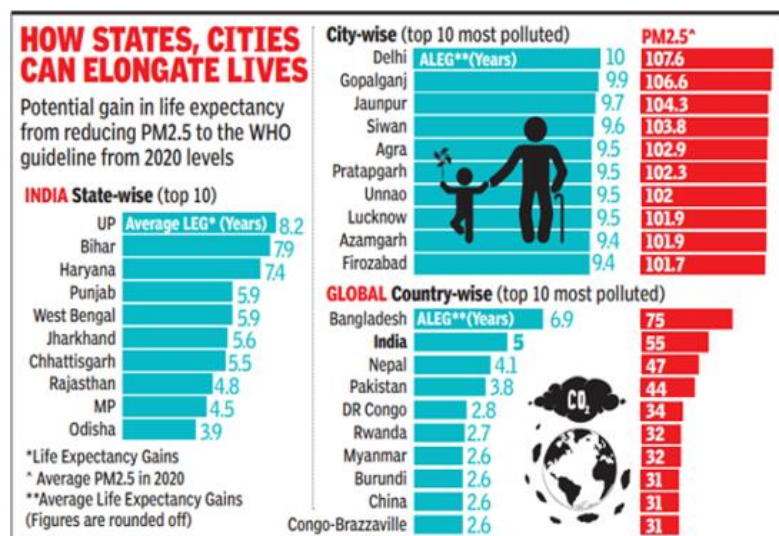


Figure 1:- Air Pollution and life expectancy

Source:- (Herald I., 2021)

New WHO Guidelines of PM2.5

According to the new World Health Organization (WHO) Guidelines, $5 \mu\text{g}/\text{m}^3$ is the new guideline which was $10 \mu\text{g}/\text{m}^3$ earlier. Dr Sundeep Salvi expressed that there is hardly any place in India that follows WHO norms.

Green Building Rating Systems and Air Quality:-

It is a well-known fact that Indoor air quality had a direct impact on the health of building occupants. Lower-grade Ventilation can affect the building occupants mentally and physically. Adverse air quality can result in short-term and long-term problems. Short-term problems such as Irritation in the eyes, agitation, dizziness and fatigue, while long-term problems are asthma, respiratory disease, heart disease and cancer.

Globally, Green Rating Systems are adopted as an experimental tool with the belief that they can make building more climate-responsive. It is also believed that the adoption of Green Rating Systems can protect building users from the ill effects of climate change inside the building.

Green Building Rating Systems may be defined as the assessment tool that is used to assess a building project based on certain standardized parameters related to building performance with respect to local conditions. The main aim of this certification is to make the building more climate-responsive with the belief that it will reduce the ill effects of climate change and make the building more comfortable for the occupants. It was also believed that these Green Building Rating System also covers the methodology of maintaining good quality air inside the building spaces.

THE OBJECTIVE OF THE RESEARCH:-

- 1) To identify and compare different Air Quality parameters in different Green Rating Systems.
- 2) To analyse the Green Certified Health Care Buildings with respect to Air Quality parameters.
- 3) To get and analyse the expert's perception regarding the current Green Rating Systems used in India and Globally.
- 4) To identify the points of modification of these Green Building Rating Systems after COVID

RESEARCH METHODOLOGY:-

The cross-sectional study was carried out under which four Hospitals certified under different Green Building Rating Systems used in India are selected. The basic purpose behind this kind of selection is to get comparative results on the basis of the Air Quality parameter used in the Green

Building Rating Systems of India. According to the report (Herald I. , 2021) Delhi was shown as the most polluted city in India so the majority of the cases are selected from Delhi.

In order to get the experts Perception, the professionals involved in the development of different rating systems, green building evaluators, and leading architects using Green Building Certification systems are selected. Around 66 experts responded to the survey and discussions with these experts are shown in the results and inferences. Further, the experts perception is also evaluated on the basis of the Z test.

Green Building Rating Systems of India:-

There are majorly three Green Building Rating Systems used in India that are as follows:-

- **GRIHA v 2019 (Green Rating for Integrated Habitat Assessment)**

GRIHA is the first adopted national rating system in India. The overall points of the rating system are 100. As shown in **Figure 2** Indoor Environmental comfort parameter weightage covers 12% of the overall weightage. As shown in Error! Reference source not found. Indoor Air Quality Covers 6% of the overall weightage of the rating system. The segregation of the Indoor Air Quality parameter is further described in **Table 1**.

Air Quality Monitoring Covers:- CO (Carbon Monoxide) and CO₂(Carbon dioxide), Temperature and Humidity.

Table 1:- GRIHA V 2019 - Indoor Air Quality Parameter and Credits

Source:- (GRIHA, 2021)''

S. No.	Indoor Air Quality – GRIHA	Credits
1	National Air Quality Standards (NAAQS) by CPCB are followed and fulfilled	1 Point
2	Minimum requirement of ASHRAE standard 62.1-2010, Section 4-7 Ventilation for Acceptable Indoor Air Quality, or NBC 2016 Volume 2, Part 8, Section 3 for Fresh air	1 Point
3	Ensure Continuous monitoring of CO, CO ₂ , temperature and RH and meet the guidelines by ISHRAE standard 10001:2016, Table 6 for all habitable areas and Installation sensor for the spaces	2 Points
4	Ensure that all sealants used have low VOC	1 Point
5	Ensure improved air quality by adopting any three strategies – Installation of plants, Promoting the use of carpets and mats at all entrances, Use of green cleaning products for housekeeping, Installation of separate exhaust systems for janitor /storage rooms for chemicals, Filtration of microbes, isolation system UVGI system negative ionization, demand control ventilation.	1Point

- **GEM (Green and Eco-friendly movement)**

As per a report (ASSOCHAM, 2020), GEM is the new Green rating System introduced in India in the year 2019. This green rating system is based on 28 principles with a total score of evaluation of a building out of 130. As shown in **Error! Reference source not found.** the comfort parameter covers around 15% of the total points. Indoor air quality weightage is around 6.9% (9 Points) which also includes indoor air quality (6 Points) and low exposure to VOC (3 Points).

Air Quality Monitoring:- AQI covers only CO₂ (Carbon dioxide) monitoring.

Gem Rating System covers the ASHRAE guidelines 62.1.2010 using ventilation procedure. It focused on the ventilation required in different spaces with different occupancy ratios in the ratio in different functions. It also focused on the recommendations regarding the usage of filters in different spaces. It also recommends that the distance between the opening and the source of the ventilation should be as per guidelines in ASHRAE.

- **IGBC Volume – Indian Green Building Council**

According to the technical guide (IGBC, 2016) Indian Green Building Council (IGBC) came into existence in the year 2001, and it is the initiative of “The Confederation of Indian Industries ”(CII).

The overall Points of the building evaluation are out of 100. As shown in **Figure 2** The Comfort parameters are covered under “ Indoor Environmental Quality “, with a total weightage allocation of 12% of the total Building Evaluation points. Out of which air quality parameter is given the weightage of 8 Points.

Table 2:- IGBC parameters of Indoor Environmental Quality
Source:- (IGBC, 2016)

S. No.	Indoor Environmental Quality	Credits
1	Minimum Fresh Air Ventilation:- Guidelines of ASHRAE 62.1-2010 standards for mixed and natural ventilation should be followed and for healthcare buildings ASHRAE 170-2008.	Required
2	Tobacco Smoke Control:- to prevent non-smokers from getting health problems from passive smoking.	Required
3	CO₂ Monitoring:- CO ₂ monitoring is required for the high occupancy area. The use of demand control Ventilation.	1 Point
4	Daylighting	2 Points
5	Outdoor Views	1 Point
6	Minimise Indoor and Outdoor Pollutants:- The main objective is to maintain a standardised air exchange rate and use appropriate filters and Germicidal Lamps for the mechanically ventilated area	2 Points
7	Low Emitting Material:- the primary aim of this parameter is to select the appropriate material which can reduce air pollution inside the space. Avoid the material which has the content of VOC and HCHO.	3 Point
8	Occupants Well Being Facility	1 point
9	Indoor Air Quality after Construction and Before Occupancy:- The process of the measurement as per Iso standards HCHO (27 ppb)- ISO 16000-3, Particulate ₁₀ (50 mg/m ³)- ISO 7708, Total Volatile Organic Compound (500 mg/m ³)- ISO 16000-6, Carbon Monoxide (9ppm) – ISO 4224.	1 Point
10	Indoor Air Quality Management During Construction:- Planning of Air Quality management during construction activities.	1 Point

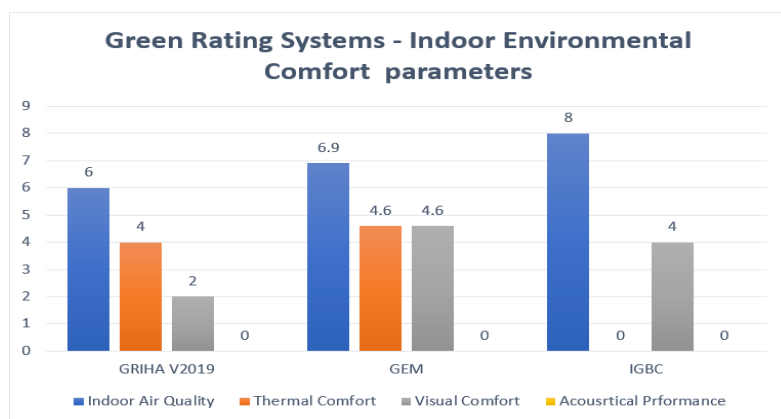


Figure 2 Green Rating Systems Comparative Comfort Parameters Weightings in Percentage
Source:- Author

RESULTS AND INFERENCES:-

The following is the compilation of the air quality measurement results at different health care buildings:-

Table 3:- Case Study Analysis of Health Care Buildings certified under Different Green rating Systems of India.

S. No.	Hospital & Place Green Building Certification System and Rating	Polluted Areas above the normal range of Air Quality	Quality of Air	Indoor Air Pollutants and Climatic Parameters							
				HOHO	VOC	PM _{2.5}	CO	CO ₂	Temp.	RH	AQI
				mg/m ³	mg/m ³	µg/m ³	ppm	ppm	°C	%	
1	Hospital A New Delhi	X- Rays area	Harmful	0.453	2.178	006	416	1396	26	53	06
	IGBC Silver	All ICU	Serious	0.811	4.404	010	853	2170	25	53	06
		O.T.	Serious	1.020	5.997	001	923	2492	25	53	06
		Blood Bank	Harmful	.699	3.620	004	483	1543	26	54	06
2	Hospital B Gurgaon	X-Ray	Harmful	0.421	1.973	006	396	1349	26	54	05
	TERI - GRIHA	ICU	Harmful	0.668	3.451	005	543	1669	26	54	06
	4 Star	O.T.	Serious	1.167	6.943	010	920	2490	26	54	06
		NICU	Harmful	.640	3.379	005	543	1669	26	54	06
3	Hospital C Delhi	ICU	Serious	1.088	6.394	009	843	2240	26	54	06
	GEM certification	O.T.	Serious	1.150	7.187	009	860	2309	26	54	06
	5 GEM	Cosmetic surgery	Harmful	0.411	1.937	006	396	1349	26	54	05
4	Hospital D Jaipur	ICU	Serious	1.151	7.235	006	920	2490	29	38	06
	IGBC	O.T.	Danger	1.167	8.230	012	943	2533	31	36	06
	Platinum	Dialysis Unit	Serious	0.506	2.440	009	396	1630	29	35	05

The names of the hospitals are not shown at the request of the hospital administration.

Hospital – A:- Hospital A is the Green Certified Hospital in Delhi under the IGBC certification system and had awarded a silver rating. As shown in Table 3, it is observed that some of the important areas like X-Ray Rooms and Blood banks have Harmful Air Quality. These areas have high values of Formaldehyde (0.453,0.699 mg/m³), Volatile Organic Compound (2.1748,3.620 mg/m³), Carbon Monoxide (416, 483ppm) and Carbon Dioxide (1396, 1543ppm) respectively. In the same way, the Air Quality of the Intensive care unit and Operation Theatre is worse. The reason is the same: the values of Formaldehyde, Volatile Organic Compounds, Carbon Monoxide and Carbon dioxide are extensively above the normal standards. The value of the pollutant PM_{2.5} (Particulate Matter) is within the controlled limits in all the spaces. There are some spaces like the Services Lobby and Cafeteria Kitchen where Air Quality is found in a poor state as the values of the pollutants except PM_{2.5} is above the prescribed standards.

Hospital B – This hospital is one of the prime hospitals in the Delhi – NCR region and is in Gurgaon. This hospital is GRIHA – 4 Star Rated hospital. On evaluating the air quality parameter, it was found that important areas like the x-ray room, ICU and NICU showed harmful air quality. The air pollutants like Formaldehyde (0.421,0.668,0.640 mg/m³), Volatile Organic compounds (1.973, 3.451, 3.379 mg/m³), Carbon Monoxide (396, 543,543 ppm), Carbon Dioxide (1349,1699,1699 ppm) were way above the normal Air Quality standards. As shown in Table 3, Operation Theatre is showing the worst air quality in the building as pollutants like formaldehyde (1.167 mg/m³), Volatile Organic Compounds (6.943 mg/m³), Carbon Monoxide (920 ppm), Carbon dioxide (1669 ppm) were very high than normal air quality standards. The values of air pollutants like PM_{2.5} (

Particulate Matter) are under control. Some areas, like the ICU lobby, etc., show poor air quality as the pollutants except

PM_{2.5} are showing higher values than the normal values.

Hospital C – This hospital is one of the best cancer hospitals in India and Asia. The hospital is Green certified under the GEM rating system and awarded 5 GEM ratings. As shown in areas like ICU and O.T., there are severe problems with air quality. Here are the values of the air pollutants like Formaldehyde (1.088, 1.150 mg/m³, Volatile Organic Compounds (6.394,7.187 mg/m³), Carbon Monoxide (840, 863 ppm), Carbon dioxide (2240, 2309 ppm) are severely above the average air quality standards for the health care buildings. The values in the cosmetic surgery area are also showing a similar trend.

Hospital D – A renovation was done with the old building, and now this building is certified Platinum Rated under IGBC. A similar trend can also be seen in this hospital, but the footfall of the patient is significantly less in this building. Critical areas like the Intensive care unit and Operation Theatre show severe air quality problems. The values of the Air pollutants like formaldehyde (1.151,1.167mg/m³), Volatile Organic Compound (7.235, 8.230 mg/m³), Carbon Monoxide (920, 943ppm) and Carbon dioxide (2490, 2533 ppm) are very high as compared to the usual air quality standards in the health care buildings.

Questionnaire Results:-

- 1) As Shown in **Error! Reference source not found.**, around **78.79%** of the experts strongly agreed, and approximately **21.21%** of the experts agreed that after COVID – 19, there is a **need for modification of Green Rating Systems**. Experts expressed that specific gaps were exposed during COVID as Green Buildings could not perform properly during this emergency.

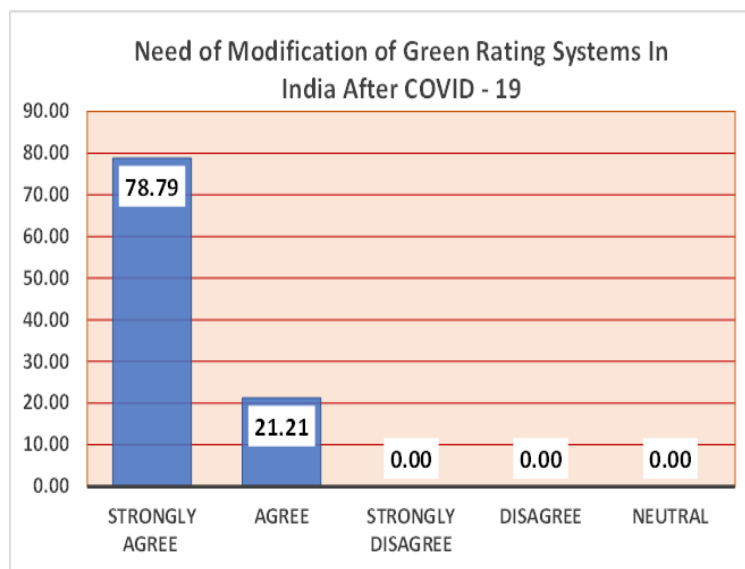


Figure 3 :- Need of Modification of Green Rating Systems in India. Source :Authors

- 2) Experts also expressed a strong need for change in the weighting of the parameters of the present Green Rating System. As shown in **Error! Reference source not found.**, Around **92.42%** of the experts strongly agreed, and around **7.58%** agreed that there is a need to change the parameters of the present Green Rating Systems used in India.

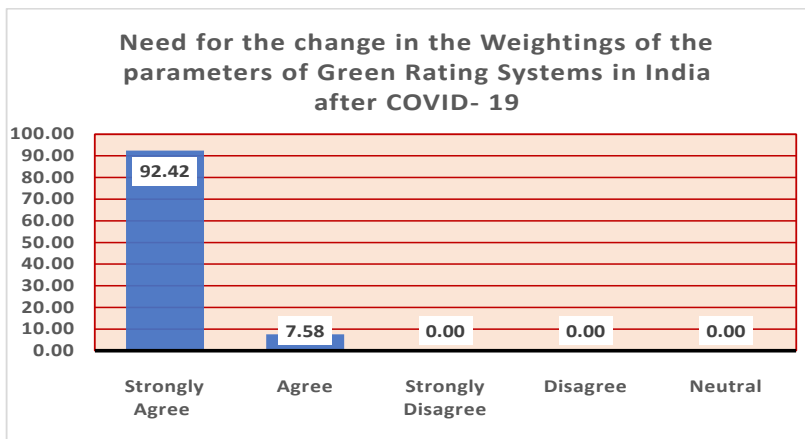


Figure 4 Need for the change in the weightings of the parameters of Green Rating Systems in India

3) According to the experts, Indoor air quality or Indoor Environment should be given more priority as compared to the other parameters; as shown in figure 5, around **83.33%** of the experts are in favour that Indoor Air quality should have more weighting than any other parameter of the Green Rating System. **9.09 %** of the experts favour giving maximum weightage to Safety and Security and **3.03 %** to Energy Efficiency and Water Efficiency, respectively. Only 1.52% of the experts opted for material and resources.

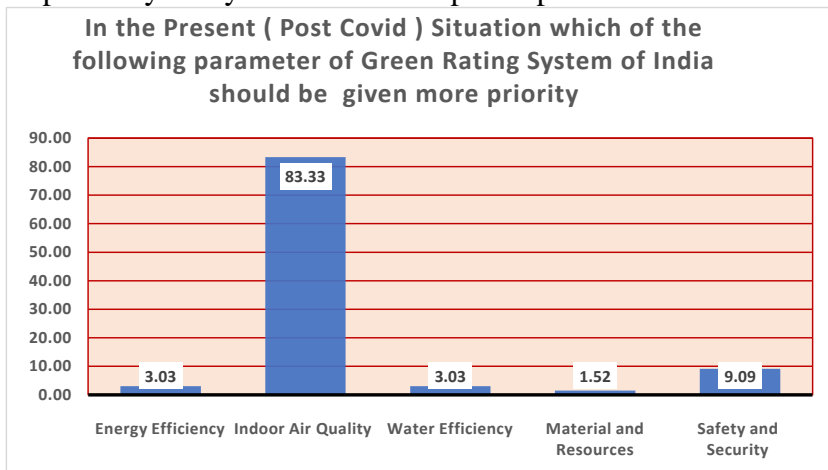


Figure 3:- In present COVID- 19 situation which of the following parameter of Green Building Rating Systems should be given more priority Source :- Author

4) According to Figure 6, Experts are not happy with the weighting allocation and structure of the air quality parameter. Around **39.39%** of the experts are strongly dissatisfied, and **43.94%** of the experts are dissatisfied with the emphasis given to the air quality parameter in the Green Rating System. Around 10.61% of the experts remain neutral, and 7.58% of the experts are satisfied.

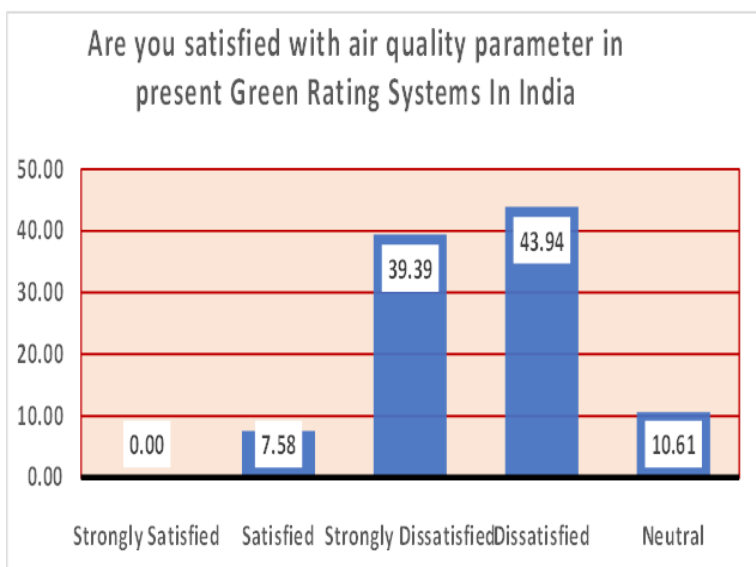


Figure 4:- Are you satisfied with air quality parameter in present green rating systems

5) As shown in Figure 5, around **50.0%** of the experts strongly agree, and approximately **46.67%** of the experts are in favour of making Air Quality Monitoring a mandatory part of the rating system as Energy Efficiency and Water Efficiency are already in the present Green Rating System. Around **6.06%** of the experts chose to be neutral for the same.

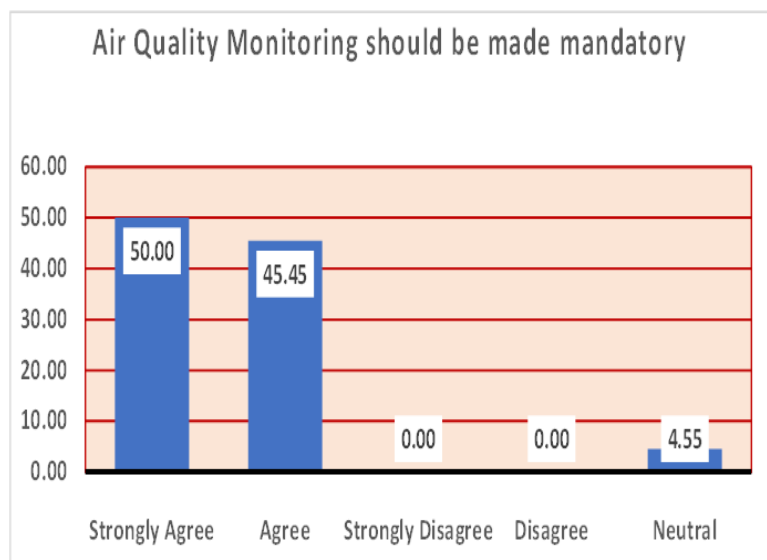


Figure 5:- Experts Response to Air Quality monitoring should be made mandatory

6) As shown in **Error! Reference source not found.**, around **39.39%** of the experts are strongly dissatisfied, and **50.00%** are dissatisfied with the current monitoring system of Green Rating Systems of India, which includes only CO₂ monitoring is optional too. Only **10.61%** of the experts are satisfied with the CO₂ monitoring system.

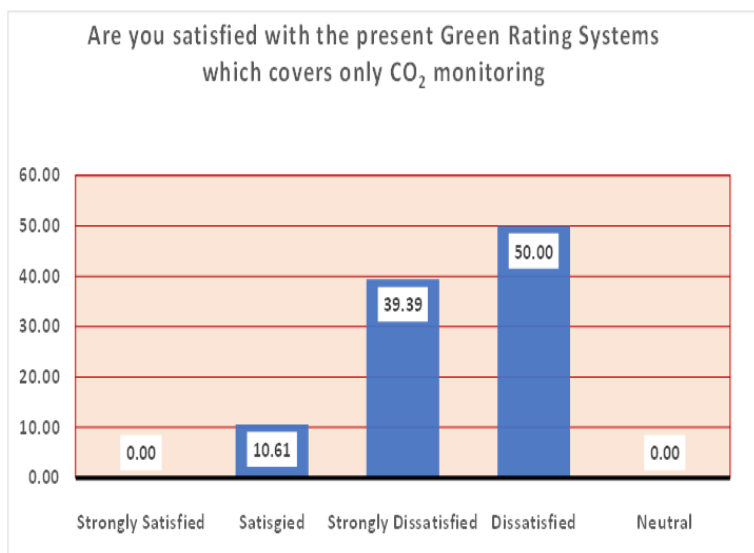


Figure 6 Experts response on present CO₂ Monitoring of Green Rating System

7) As shown in Figure 7, around **84.85 %** of the experts are in favour of including VOC(Volatile Organic Compound), HCHO (Formaldehyde), PM_{2.5}(Particulate Matter), CO (Carbon Monoxide) and CO₂ (Carbon – dioxide) as part of the indoor air quality monitoring for building paces. Around **4.55%** of the experts are in favour of CO (Carbon Monoxide), and 10.62 % of the experts are in favour of CO₂ monitoring only.

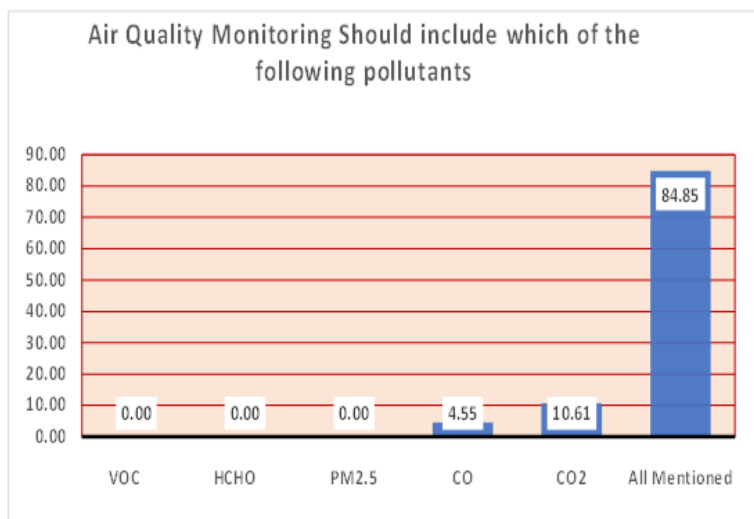


Figure 7:- Experts Response on which pollutant should be included in monitoring system of Green Rating System

- 8) As shown in Figure 8, most experts are not satisfied with the emphasis given to natural ventilation in the present Green Rating System in India. During Covid- 19 Natural Ventilation was the key to the survival of the users inside the building. Amongst experts, **36.36%** are strongly dissatisfied, and around **63.64%** are dissatisfied. According to them, more weightage should be given to the design, which uses natural ventilation.

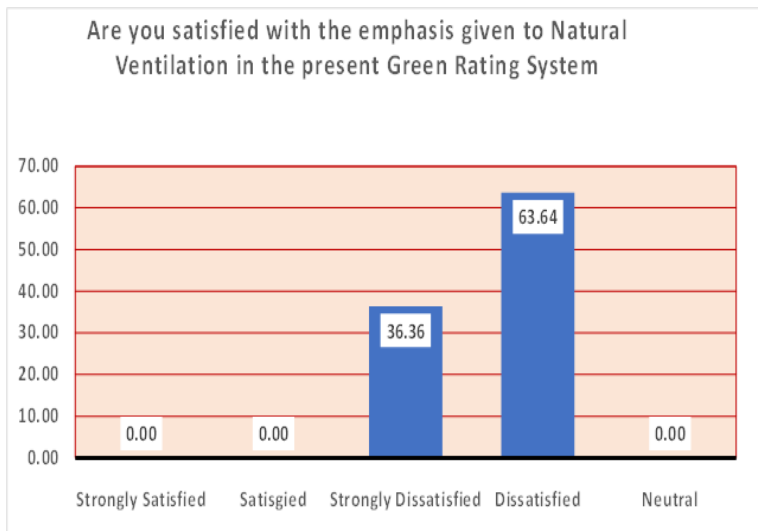


Figure 8:- Experts opinion about the emphasis given to Natural Ventilation in present Green Rating System

- 9) As shown in figure 11, almost 100% of the experts are in favour of displaying air quality monitoring, especially in large gatherings or critical health care spaces. Around **40.91%** of the experts strongly agree, and **59.09%** of the experts agree on the same. This will give the building users an idea of what air they are breathing.

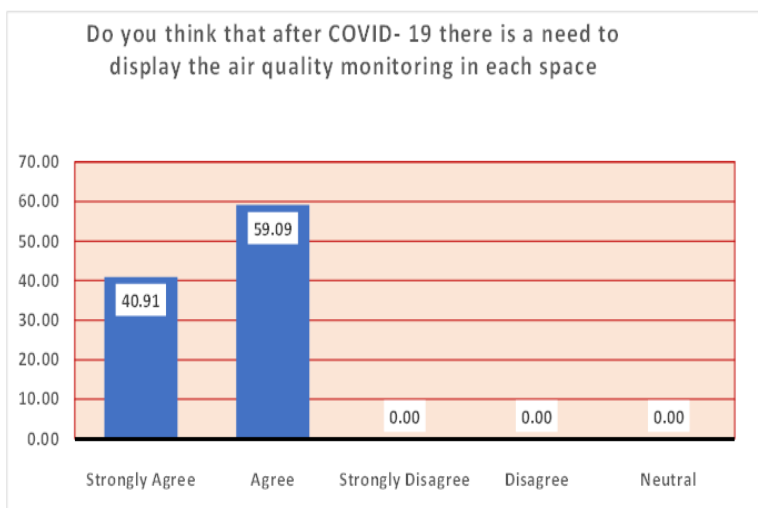


Figure 9 Experts opinion about the display of air quality monitoring especially large gathering space

10) As shown in Figure 10, most experts agreed that improving air quality parameters by giving more weightage will give a better and more efficient rating system. Around 50.00% of the experts strongly agreed, and approximately 45.45% of the experts agreed on the same. Therefore overall, 95.45% of the experts are confident that Green Rating Systems of India will improve with the improvement in Air Quality parameter.

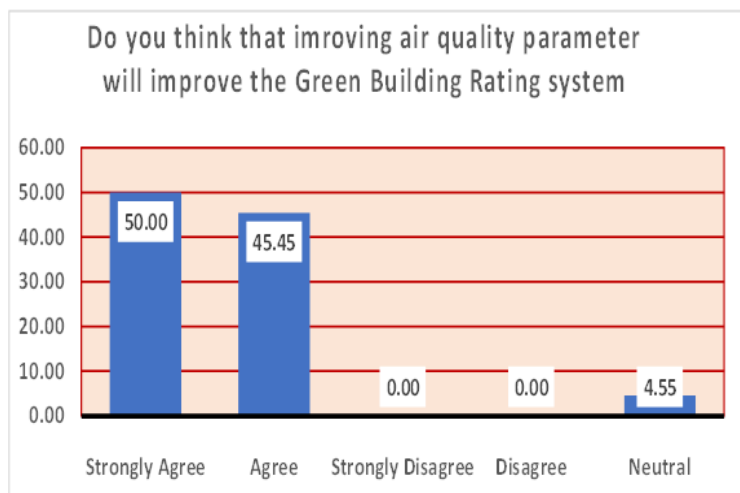


Figure 10:- Experts response on improving air quality will give more efficient Green Rating Systems

TABLE 4:- Expert's Perception reliability check of Questionnaire							
Points of Consideration	Hypothesis	Sample proportion 's'	Expected Population proportion 'p' & q=1-p	Z calculated = $s-p/\sqrt{[(p*q)/n]}$	Z Tabulated	Result	Inferences
1) Indoor Environmental & Air Quality							
1) Need for modification of Green Rating System	H ₀₁ = It is believed that 70% of Experts agree that there is a need for modification of the Green Rating System H _{a1} = It is thought that greater than 70% of the experts agree that the Green rating System needs to be modified.	1	.70	5.31	1.645	H ₀₁ is Rejected H _{a1} is Accepted	More than 70% of the Experts favour the modification of the present Green Rating Systems of India.
2) Need for the change in the weighting of the parameter of Green Rating Systems	H ₀₂ = It is believed that 70% of experts agree that there is a need for change in the weightings of the parameter Green Rating Systems of India. H _{a2} = It is believed that greater than 70% of experts favour a change in the weighting of the parameters of the Green rating Systems.	1	.70	5.31	1.645	H ₀₂ is rejected H _{a2} is accepted	More than 70% of the experts agreed that there is a need to change the weighting o the parameter of the present Green Rating Systems.
3)After Covid – 19, which of the following parameter of Green Rating Systems should be given priority	H ₀₃ = It is believed that 70% of experts agree that after Covid – 19, Indoor air quality should be given more priority H _{a3} = It is believed that greater than 70% of the experts agree that after Covid- 19, Indoor air quality should be given more priority.	.833	.70	2.36	1.645	H ₀₃ is rejected H _{a3} is Accepted	After Covid – 19, Indoor air quality should be prioritised in Green Rating System.
4)Are you satisfied with the present air quality parameter in Green Rating System	H ₀₄ = It is believed that 70% of experts are not satisfied with the present air quality parameter in the Green rating Systems of India. H _{a4} = It is believed that greater than 70% of the experts are not satisfied with the present ai quality parameter in the Green Rating System of India.	.833	.70	2.36	1.645	H ₀₄ is rejected H _{a4} is Accepted	Above 70% of the experts are unsatisfied with the air quality parameter in the present Green Rating Systems of India.
5)Air quality	H ₀₅ = It is believed that 70%	.9545	.7	4.51	1.645	H ₀₅ is	More than 70

monitoring should be made mandatory.	of Experts agreed that air quality monitoring should be mandatory. H ₄₅ = It is thought that more than 70% of experts feel that air quality monitoring should be required in the Green Rating Systems.					rejected H _{45is} Accepted	% of the experts agree that air quality monitoring should be mandatory in India's Green Rating System.
6)Are you satisfied with the present Green Rating System, which covers only CO ₂ Monitoring	H ₀₆ = It is believed that 70% of experts are unsatisfied with the present Green Rating System, which only covers CO ₂ monitoring. H _{a6} = It is believed that more than 70% of experts are dissatisfied with the present Green Rating System of India, which covers only CO ₂ monitoring.	.8939	.7	3.44	1.645	H _{06is} rejected H _{a6is} Accepted	Above 70% of the experts are unsatisfied with the present Green rating Systems of India.
7)Inadequate Air Quality monitoring should include which of the pollutants.	H ₀₇ = It is believed that 70% of experts favour including (TVOC, HCHO, CO, CO ₂ , and PM _{2.5}) for air quality monitoring. H _{a7} = It is believed that greater than 70% are in favour of including (TVOC, HCHO, CO, CO ₂ , and PM _{2.5}) for air quality monitoring.	.8485	.7	2.63	1.645	H _{07is} rejected H _{a7is} Accepted	Above 70% of the experts favour includes (TVOC, HCHO, CO, CO ₂ , and PM _{2.5}) for air quality monitoring.
8)Providing After Covid- 19 there is a need to display the air quality monitoring in each space, especially in large gathering spaces.	H ₀₈ = It is believed that 70% of experts favour displaying air quality monitoring in vast gathering spaces. H _{a8} = It is believed that more than 70% of experts favour displaying air quality monitoring, especially in large gathering spaces.	1	.7	5.31	1.645	H _{08is} rejected H _{a8is} Accepted	More than 70% of experts favour air quality monitoring, especially in large gathering spaces.
9) Are you satisfied with the emphasis on Natural Ventilation in the present Green Rating System?	H ₀₉ = It is believed that 70% of the experts are not satisfied with the emphasis given to the Green Rating Systems of India. H _{a9} = It is believed that greater than 70% of the experts are not satisfied with the level of emphasis given to the Green Rating Systems of India.	1.0	.7	5.31	1.645	H _{09is} rejected H _{a9is} Accepted	More than 70% of the experts are not satisfied with the emphasis given to the Green Rating Systems of India.
10)Do you think that improving air quality parameters can improve can make Green Rating Systems more efficient	H ₁₀ = It is believed that 70% of the experts admit that improving air quality parameters can make Green Rating System more efficient. H _{a10} = It is believed that greater than 70% of the experts admit that improving air quality parameters can make Green Rating System more efficient.	.9545	.7	3.569	1.645	H _{10is} rejected H _{a10is} Accepted	Almost 70% of the experts favour adopting sensor-based doors and windows.

Table 4:- Hypothesis based testing compiled on Expert's Perceptions about the modification of the Green Rating System

CONCLUSION & RECOMMENDATIONS:-

On evaluating the different Green Certified hospitals with respect to the air quality parameters, critical areas like the Intensive care unit, Operation theatre etc., are showing severe problems. Air pollutants show much higher values than the usual air quality standards. The air quality performance of the healthcare buildings indicates that significant revision is required in the air quality parameters of the present Green Rating Systems used in India.

The proposed questionnaire was effective in finding the expert's view related to different aspects of Green Rating Systems and the need for modification of these Green Rating Systems. he presents the

green rating system of India and after Covid- 19 if there is a need for improvement of the parameters.

The Hypothesis testing results are written as follows:-

- Majority of the experts felt that there is a need to modify the existing Green Rating Systems and its parameters after Covid – 19 as certified buildings are not performing as per certified standards.
- During the literature review, Six Green Rating Systems were studied, and it was found that the percentage credits related to air quality parameters varied between 6-8% experts advocated strengthening air quality by increasing the weightage. The percentage increase in the weightage of the Air Quality Parameter is subjected to further research.
- Experts also advocated adopting a proper monitoring system in the present Green Rating Systems to give the building occupants a healthier and more suitable environment.
- Experts are in favour of including the continuous monitoring of pollutants like VOC (Volatile Organic Compound), HCHO (Formaldehyde), PM_{2.5} (Particulate Matter), CO₂ (Carbon dioxide), and CO (Carbon Monoxide). Experts also express the need to display these pollutants' value in large gatherings.
- The experts also expressed the importance of natural ventilation during the time of Covid- 19; therefore, they favour giving more emphasis on natural ventilation.

RECOMMENDATIONS:-

- Hospital studies and Comparative Weightage study, Questionnaire responses from experts had displayed less weightage is assigned to the air quality parameter in the present Green Building Rating Systems of India.
- The recommendations of the experts can be taken into consideration in the modification of the Green Building Rating Systems of India. Allocation of higher weightage to the air quality is subjected to further research.

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