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Research Paper

Ill Effects of Moisture in Indoor Environment and Measures to Control It

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***ABSTRACT**: In India there is a large amount of humid air beside the coastal regions. Due to these coastal areas there is tremendous amount of wind speed going. The humidity levels in these regions keep changing due to rainfall and annual radiations.*
The wind speed in the coastal region is high, which is helpful for the circulation of air for passive ventilated structures. But, with the wind speed, comes the enormous amount of humidity. Humidity encourages the fungal growth which causes the respiratory problem in humans. So for a healthy habitable space, the rising level of moisture in the atmosphere is not recommended. So, the main purpose of the report is, how can the moisture in the habitable space can be reduced for making the indoor environment healthy.
KEYWORDS: Passive ventilation, local materials, desiccant material, water maker.

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I. INTRODUCTION

AIM: TO STUDY THE ILL EFFECTS OF MOISTURE IN THE AIR AND IDENTIFY THE TECHNIQUES TO REDUCE IT AND CONTROL IT IN INDOOR ENVIRONMENT.

OBJECTIVES :

- To study the moisture levels in various coastal regions of India.
- To study the effect of ,moisture on human health and also the effects of moisture on building material
- To identify various techniques to control the humidity in air by active as well as by passive methods.
- Identify effects of moisture on traditional material as well as on contemporary materials; and also its properties with respect to moisture-effects.
- Identification of passive and active techniques to reduce the moisture content in indoor environment.
- Maintenance related solutions to clean the fungus from surface of building material.

SCOPE : To study the ill effects of moisture in air and how it affects human psychology and building material in indoor environment.

In humid regions, there is ample speed of wind for circulating the air deep in the space, but also contain huge amount of moisture with it. The research might help to utilize the air for ventilation, decreasing the quantity of humidity in it, thus supplying dry and natural air into the habitable space.

II. LITERATURE REVIEW:

The indoor air quality in habitable spaces is considered as major risk factor for human health and psychology. Consideration of such an issue is important, because pollution from outdoor environment spend an adequate period of time indoors. Such hazardous quality of air do affect the human body in residential spaces, hospitals , old age homes, retirement homes, day-care centres, etc. on the basis of age and other respiratory factors.

The main reason is the microbes, which grow on surfaces due to the moisture. It is been clinically proven that the exposure to such microbes are responsible for allergies, asthma and many other decreases related to respiratory tract. Specific biological agents are mostly heterogeneous, listing from spores to pollens of plants, from algae to fungi and particular protozoa.

The polluted air from the outdoor environment includes smoke from the transport due to the fuel consumption and also some amount of biohazard agents such as plant pores & pollens and droplets of chemical

fluids. These things consist of large amount of bacterial and fungal species, which have potential to grow in indoors with adequate availability of moisture level. A large amount of such biological agents contribute to dampness and also low air circulation.

In India there is a large amount of humid air beside the coastal regions. Due to these coastal areas there is tremendous amount of wind speed going. The humidity in these regions increase/decrease due to climatic conditions and annual radiations.

Following are the reasons due to which the dampness arises in the indoor environment:

1) Improper installation of majors took to save energy(i.e. building envelope, defective ventilation and inappropriate insulation)
2) Building types and density, urban degradation and socio-imbalance.
3) Imbalance in weather conditions and shifting climate zones.
4) Globalization of construction techniques and materials.

Table 1: Moisture levels in various coastal regions of India

CITY	M.S.L.	CLIMATE	AVG TEMPERATURE	MAXIMUM RAINFALL	RELATIVE HUMIDITY	VAPOUR PRESSURE
MUMBAI	11	W&H	38.4	1240 mm	81%	27.4
RATNAGIRI	91	W&H	34	872mm	74.25%	24
PANJI	60	W&H	33.4	861mm	82.41%	27.4
KOCHI	3	H&H	32.9	705.8mm	83%	26.36
TRIVANDRUM	64	H&H	33.2	330.4mm	85%	28.69
VISHAKHAPATTANAM	3	H&H	36.2	258mm	78%	27

Effects of Humidity, Indirectly Affects the Human Health

In every country, indoor air quality is recognized as major factors which can disturb the human health.The main reason is the microbes, which grow on surfaces due to the moisture. It is been clinically proven that the exposure to such microbes are responsible for allergies, asthma and many other decreases related to respiratory tract. Specific biological agents are mostly heterogeneous, listing from spores to pollens of plants, from algae to fungi and particular protozoa. Microbes growing on the surfaces consist of hundreds of bacterial and fungal species which need just a minute per cent of moisture to grow. If a human body comes in contact with them, the body may show signs of problems w.r.t. respiration, allergies and also asthma.

Human health is totally dependent on the air quality, and there is a vast difference between the indoor air qualities w.r.t. outdoor air quality. The team working with WHO recommended guidelines for two types of categories which can be major risk factor with respect to health issues in habitable space. Biological agents suitable for health are extensively nitrogenous varying from plants spores and pores to bacterial, fungal, algal species and bit protozoa exude out or inside the environment. Biological agents do contribute to dampness in indoor environment. Growth of microbes like moulds, fungus, bacterial agents who emit spores grow into the indoor environment because of the outrage of the moisture level.
(WHO guidelines for indoor air quality : dampness and mould)

III. DAMPNESS IN THE INDOOR ENVIRONMENT AND ITS EFFECT

In several countries the studies show the 20% of building showing the signs of dampness. Indoor air is a mixture of living and dead microbes, fungus, toxins allergens and VOCs. Dust mites and types of some fungus are responsible for allergies and asthmatic problems, because of some of them are able to generate toxins responsible for problems related to respiration.

Dampness in an indoor environment indicates that there is poor ventilation resulting to which there is growth of biological hazards and also the VOCs. Further the stagnant water and growth of fungus do attract rodents which relay the bacteria further.
(WHO guidelines for indoor air quality : dampness and mould)

3.1. Dust mites

Dust mites are related to rodents like ticks and spiders which are not visible to human eyes, which are present on human skin and feed on human scales, grow because of excess of moisture. (WHO guidelines for indoor air quality : dampness and mould)

3.2. Fungus

Fungi are ubiquitous eukaryotic organisms with maximum species. They can enter the indoor environment through passive-type vents and also active-type. Due to such ability it is present on every surface. But the main thing to remember is that, such fungi deposited on surfaces do need moisture for growth.

Funguses are in demand of nutrition including carbs, proteins and lipids. The platform for their growth are vast ranging from floral to fauna matters and also layers on surfaces of materials such as oil deposits on kitchen walls, paints and varnishes on walls and other stored food products in the indoor environment.

(WHO guidelines for indoor air quality : dampness and mould)

3.3. Bacteria

They are present on every surfaces present in the indoor environment and damp spaces. The main origin of their growth is from air flowing from outdoor to indoors, living entity in the house and factors present inside the house itself.

(WHO guidelines for indoor air quality : dampness and mould)

3.4. Protozoa

Protozoa are the main reason behind the infusion of viruses that add-up to sever health effects which are directly related bad indoor environment. (WHO guidelines for indoor air quality : dampness and mould)

IV. EXPOSURE BY A HUMAN BODY

The exposure happens when a human body comes in contact with pollutant for a period of time when the concentration is at the peak. Answering the questions can be an important indication for exposure happened. (WHO guidelines for indoor air quality : dampness and mould)

V. VENTILATION & CONTROLLING MOISTURE

Dwellings provide protection from the climate for humans. The local materials & tradition plays a vital role in the design of building. Building codes directly take care of buildings quality, safety & health of living beings and also use of resources sustainably. It also takes care of energy management and reduces impact on the environment.

The main purpose behind the ventilation is to mitigate the pollutants present inside indoor environment and also to control the thermal environment and humidity. To make the space indoors healthy, it is most necessary to discard the pollutants and humidity or to dilute their concentration to maintain the structural integrity.

Ventilation can be provided either by natural or by mechanical means. They do enhance the health, but sometimes may also have adverse effects too, if they are not been maintained or have a defect in design. If got faulty, they may even supply hazardous substance in the living environment which may degrade the components indoors.

With the circulation of air, it also carried the moisture from outside to inside environment. Humidity is considered vital criteria while considering the outdoor ventilation.

In hot climates, the commercial buildings are been unified with air conditions for ventilation. These air condition systems are often fused with humidifiers which may also add-on to expressive humid air, chemicals or microbes in the space indoors.

It is been proved that the prominent symptoms for sick building syndrome are related to heating, ventilation and air conditions of the building. Among these the chances are more in air-conditioning systems than other two. Thus the points states that for a healthy indoor environment it is necessary to maintain the machines and trimming the ill effects of the above 3 characteristics.

The body getting in touch with the pollutants generated from indoor activities and emissions from air conditionings systems might showcase a vast array of sever effects similar to cancer or diseases related to respiratory tract. Following are the affirmative and negative effects of passive and active ventilation systems.

A proper vent system of air do lower the viral and bacterial concentration spread by air. Thus higher the ventilation rate, lower is the changes of the spreading the hazard.

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VI. VENTILATION SYSTEMS

6.1 Passive ventilation

Passive vent is basically the circulation of outdoor air made possible passing through indoors by creating pressures, thus there is no use of fans and any other ventilation system. The rates of natural ventilation depend on the sizes of inlets and outlets and also the speed of wind and its direction. Circulation of air can also be done by stack effect by creating a pressure difference. In extreme climates, the sizes of the openings play a vital part in ventilating the space.

6.1.1 Advantages

I. Natural vent is well suited in moderate climates
II. Maximum circulation rate for cooling.
III. it has less maintenance w.r.t. mechanical
IV. Less in cost as compared to mechanical system.
V. No noise created, thus keeping the space quiet and calm.

6.1.2 Disadvantages

I. Natural vent work poorly in extreme climates, where excess of cool air do cause discomfort and loss of more energy may lead to condensation.
II. This might lose the control over the ventilation rates, which can harm the indoor comfort and lead to energy loss.
III. There might me disruption of fresh air circulation over a larger and deeper spaces.
IV. Natural vent is not suited for spaces surrounded by neighbourhood with noise and pollution.
V. Security is one of the risk factor.
VI. These systems do-not filter or purify the incoming air.
VII. In humid climate this ventilation doesn't escape from stopping the damping of walls and fungal growth on them.

6.1.3 Types of Passive Ventilation

Single sided ventilation

In this type the air circulates through the space from a single opening which acts as both inlet and outlet. This type is not of a good practice as there is less control over wind and the circulation is unstable.

A. Cross flow ventilation

In cross flow ventilation the openings are on 2 sides of the space i.e. on parallel walls. Air is made to enter the space from one opening and exit from other. This said to be the best and hybrid system practiced. The pressure difference is created by analysing the sizes of opening and wind speed, hence the ventilation rate is been achieved. This system is the most controlled as it is based on cross flow system, but has its own limitation for deeper and larger spaces.

B. Wind tower

This type acts as a stack vent, where the fresh air enters the space from the window i.e. Positive pressure, but the outlet is from stack i.e. negative pressure point. As the air absorbs the heat from the space it rises and gets out through the stack. Thus the cycle continues. Such system is majorly use in hot regions where the radiation are been used to rise the temperature of the stack's opening which creates negative pressure.

C. Atrium ventilation

A hollow puncture is been provided in the buildings with deeper spaces which is open from top to bottom of the building. This hollow puncture is covered by glass so as-to protect it from bad weather and also allow the natural light run deep into the space. This atrium helps to circulate the air so as to keep the building well ventilated. The whole thing in itself acts as a stack.

6.2 Types of Ventilation through Mechanical Means

Mechanical vent is established on the rate of ventilation needed throughout the year in all weather conditions. Building envelope is been provided with fresh air supply and exhaust and is sealed and made impermeable so as to prevent infiltration and energy-loss. Moisture and air quality factors play a major role in such type of ventilation. Heating and cooling system can also been provided in such type of ventilation.

6.2.1 Mechanical Exhaust Ventilation

The mechanical exhaust system the air containing the pollutants and other particles is drained out from the habitable space. Fresh air is been taken inside by passive means and for an exhaust, a central fan is connected to all the rooms. This fan sucks the low quality air from the space and throws out, thus circulating the fresh air simultaneously.

The circulation rates are constant and a small negative pressure at the exhaust thus prevents from moisture getting condensed on the wall surface, hence arresting the growth of moulds.

6.2.2 Hybrid (Mixed-Mode) Ventilation

Usually for improvement in circulation of natural air from outdoor to indoors, some low-energy mechanical means can be used. This is basically hybrid system, where passive ventilation is combined with some mechanical technique for circulation of fresh air, where a fan can be used with duct so as to blow the air and also exhaust it, in deeper spaces. of all this, buildings orientation plays a primary role, so as to make passive vent work. Depending on the climatic conditions, hybrid systems do work for multi-storey buildings, shopping malls, etc. in some cases, passive and active means are provided separately so as to switch them whenever needed. This is widely done in extreme climatic conditions.

VII. MATERIALS

The most common traditional materials used for construction of houses in humid climate included

- Mangalore tiles for roofing,
- laterite stone for walls,
- lime as a mortar,
- palm leaves for roofing
- bamboo
- clay

These materials were found abundant in local; hence it affects less on environment. So based on the thermal transmittance and local availability of such materials, structure were easy to build and tackle the climatic condition of the zone.

Table 2: List of local materials

Name	Form	Density kg/m³	Thermal Conductivity W/(mK)	Specific Heat MJ/m³K
Mangalore Roof Tile	Tile - Roof	2531	0.6051	1.2809
Laterite stone				
Bamboo	Wood	913	0.1959	0.6351
Lime Powder	Powder	607	0.1286	0.7078

Table 3: Properties of various materials

Name	Form	Density kg/m³	Thermal Conductivity W/(mK)	Specific Heat MJ/m³K	Durability	Maintenance	Moisture resistance	Cost	Threat & Effects of moisture
Mangalore Roof Tile	Tile - Roof	2531	0.6051	1.2809	Not <20years	No maintenance unless breakage.	Not resistant to moisture unless coated with waterproofing membrane.	~Rs.14/pc	Normal algae growth due to prolonged climatic conditions. The tile heats up faster, eradicating absorbed moisture into it.
Bamboo	Wood	913	0.1959	0.6351	Bamboo is not so durable against the brown-rot fungi unless it is treated with heat and all of its moisture content is been removed.	Bamboo doesn't need lot maintenance as it is coated with varnish so as to prevent the fungal growth on its surface.	Because of its low density, it has tendency to absorb or release water/moisture depending on the environment. bamboo is less resistance to water and moisture unless it is relevantly treated.	~Rs.4000/ Tonne	The moisture absorption is quite high, and absorbs 100% of its dry weight, due to which it swells until it reaches the saturation point of fibre inside.
Lime	Powde	607	0.1286	0.7078	The	Once mixed	Lime powder	~Rs.400/	If used as a

Powder	r				durability of lime powder is quite less unless it is well treated with fibres for mortar preparation.	with fibres and other materials in a proper proportion for making mortar, there is no need for maintenance, unless it comes in contact with salt and moisture for prolonged time period.	do absorb moisture and water. If it comes in contact with water and salt for a long time, it gets weathered off.	kg	mortar, the lime acts as a primary path for passing moisture because of its capillary suction. Thus making the indoor space porous to outer environment. Lime used as a plaster do absorbs moisture, but has a germ killing property, thus preventing the wall from micro rodents& insects.
Basalt rock	Rock	2900	1.51		Basalt is most durable and was used for building large load bearing structure.	Rocks is just needed to shape up as a brick, and no maintenance needed once the wall is made.	It acts as moisture resistant based on temperature.	~Rs.5000/ Mt.tonne	Basalt acts differently with moisture at different temperature. If heated, it discards moisture or water content on the surface and in low temperature, it traps the moisture & vice versa.
Teak Wood	Wood	665	0.2369	0.8412	Wood is durable in certain amount of moisture content in it.	Teak needs to coat with varnish so as to stop from absorbing moisture and fungus growth on it.	Teak is not resistant to moisture, making the teak weaker.	~Rs.800-Rs.4500/ cubic feet	If it absorbs moisture it expands, and is favourable for fungal growth. If 100% moisture is discarded, it shrinks, hence
Cement plaster	Powder	278		0.9719	Cement plaster is durable for 15-20 years under favourable climate. Excess of Rainwater can hamper the strength.	Cement plaster needs to be maintained after 10-12 years under some circumstances.	Cement plaster is not resistant to moisture, unless mixed a suitable chemical into it. No resistance to water & moisture leads to seepage of water from outdoor to	~Rs.250-400/bag	Moisture absorption in the plaster may lead to moulds and fungus growth on the surface of the wall, hampering the indoor air quality.

							indoor environment		
Fire Brick	Brick	2049	1.2729	1.2887	Bricks are durable at certain amount of loads.	No maintenance required unless breakage.	Brick is not a moisture resistant material, and can absorb water 100% of its total volume.	~Rs. 4-8/Piece	It can hold water for a long time, which results in prolonged dampness of indoor environment.
Glass	Glass	2477	1.0522	1.9654	Since glass is a brittle substance, it is durable for longer time.	Maintenance needed under circumstances of breakage and air pollutants / salts deposition on the surface.	Glass do not have tendency to absorb moisture, so it is free from fungal growth.	~Rs.480 /sq. ft.	
R.C.C.	Block	2400	1.83		Durability of RCC is not so good enough.	RCC if damaged cannot be repaired, it can just be retrofitted in certain circumstances	RCC is not a moisture resistance material, unless it's well treated with water resistant chemicals. It degrades and steel inside it corrodes if required measures are not been taken while construction.		RCC surface if left exposed can be favourable for the growth of algae or fungus if stays wet for a long time.
Steel	Metal	7823	44.117	4.1896	Steel is very much durable to moisture, although it depends on the make and composition	No need of maintenance once been constructed. Can be easily replaced if needed.	Some types of steel may need layers of coating for prevention of corrosion or reactions. Steel corrodes if there is increase in humidity.	~Rs.36/kg	No fungal or algal growth on the surface, but it does corrode if faultily made.
Plaster of Paris	Powder	1000	0.1353	0.9526	Pop fails in the durability as it cracks if excess of moisture gets absorbed.	Once cracked it must be treated by breaking and plastering the chunk with no air gaps left behind.	POP is not a moisture resistant material and has tendency to absorb moisture equivalent to it overall density.	~Rs.20/sq. ft.	Pop of not coated with latex or plastic paint, can absorb moisture, hence allowing the fungal growth on the surface.
Gypsum board	Board	623	0.2527	0.6033	Gypsum board fails in durability test against moisture.	The whole sheet is to be replaced if found damaged due to moisture.	Gypsum is not resistant to moisture unless sprayed with specific coating.	~Rs.15-100/sq.ft.	There may be fungal growth on the surface if it remains wet for a long time. Can hamper the

									indoor air quality.
Autoclaved Aerat3ed Concrete Block (AAC)	Block	642	0.1839	0.794	AAC block doesn't stay strong against moisture, being a porous material it has tendency to absorb moisture.	Maintenance is not needed	AAC acts a primary passage for moisture from outside to inside environment because of its less density and porosity.	~Rs.37/pc	If not plastered, it have tendency to grow fungal coat on its surface.

7.1 Material Recommendation And Resemblance

Roof, wall and flooring are the primary elements responsible for healthy indoor environment. Thus it is important to choose the materials wisely which would retard moisture/ humidity content and be favourable for the coastal climate and act accordingly.

ROOF: Roof is the component which must be given prime attention as this component come in contact of radiation as well as outdoor humidity at maximum time of the day.

Table 4: Properties of roofing materials

ROOF				
	MANGALORE TILE	DRY GRASS	CONCRETE TILE	R.C.C. SLAB
	 Figure 1 : Mangalore Tile	 Figure 2: Dry Grass Roof	 Figure 3: Concrete Tile	 Figure 4: R.C.C. slab
Thermal Conductivity W/(mK)	0.6051	dry - 0.04 W/mK slightly moist to - 0.07 W/mK wet - 0.1 W/mK	0.5619	1.83
CLIMATE	WARM & HUMID			
Density kg/m³	2531			2400
	Mangalore tile is majorly used as the roofing materials in rural areas and most of the bungalows too.	Dry grass is used as a roofing material in most of the rural area from long time. It acts differently in different climates with respect to its physical condition. Dry grass has tendency to absorb humidity from the air. And it also gets easily heated due to its porous nature.	Concrete tiles for roofing purpose are more efficient now a day as they are available locally. They are light weight and easy to fix and have less thickness as compared to other roofing tiles. The tile don't favourable conditions, as in, growth of fungus because of some chemical compounds mixed in it while production.	R.C.C. slab consists of cement, gravels, sand, and steel in it, due to which the density is higher and is bulky as compared to other roofing materials. It has tendency to absorb water at some extinct. Bad casting of slab may even allow water to seep through it.
WINTER SEASON	Mangalore tile in cold climate, absorbs the sun radiations, this transfers the heat from outdoor to indoor environment. Due to low thermal conductivity, it gets heated fast, thus eradicating the moisture absorbed. At night time, due to lack of radiation, it again absorbs moisture from the surrounding air and blocks the heat transferred in indoors to escape.	Dry grass roof in winter season acts as insulating material. Due to this the indoor environment remains warmer which can increase the humidity level in the indoor environment. For such conditions, passive ventilation plays major role for air circulation to keep humidity in control.	The rate of heating is graters because of its low density and porosity and also because of its low thermal conductivity. Due to its less density the cooling rate is also fast as compared to the Mangalore tile. Concrete tile does not give insulation for external climatic condition because of its less thickness.	The slab in winter season remains cool throughout the day due to low radiation and high thermal density. The thermal radiations are insufficient to remove the moisture content absorbed deep inside the slab.

SUMMER SEASON	In summer season there is large amount radiation falling on the roofing surface. The tile gets heated, which allows the air to circulate indoors. Thus due to circulation, there comes least chances of spaces remaining damp.	Dry grass in summers gets heated quickly because of its low density. Thus it eradicates the absorbed moisture. this kind of roof also acts as insulator from the outdoor harsh radiation, leaving the indoor environment cool. Passive ventilation will enhance the air circulation and lower the humid air inside.	Due to the higher rate of heat gain, the temperature in indoor environment can rise throughout the day, and fall as the temperature in the outer environment comes down. Due to this property, the humidity doesn't get trapped in the given volume of the tile.	In summers due to high radiations the surface of the slab gets heated. So moisture content on the layer of slab is removed due to high sun radiations. Due to high density, the slab keeps on absorbing the heat, thus the indoor environment remains cool. Due to this there are less chances of fungal growth on the slab surface from inside as well as on outside.
RAINY SEASON	The main purpose was for an easy runoff of rain water. The tile is partly porous and absorbs some amount of water, and slides off the rest. Due to its porous nature, it has tendency to retain the moisture level. The thermal conductivity of the tile is low, thus it gets heated quickly. Due to its heating, the moisture which is leftover gets evaporated. Thus the indoor environment remains hygienic.	In rains the dry grass roof absorbs the maximum amount of water, which doesn't get evaporated by the sun radiation. Passive ventilation doesn't work in this situation because of same humid climate in both indoor and outdoor climate. The water content also promotes growth of fungus and bacteria because of its vegetative nature. And because of its insulating properties, it gets tough to eradicate this by sun radiations because of its uneven nature. Thus the roof needs to be changed after some interval so as to make a safe environment indoors.	The tile absorbs moisture more than 90% of its mass. But has tendency to roll of the water because of its water resistant layer. The moisture levels in the mass can soon be eradicated if the tiles get heated by external radiation.	R.C.C. slab in rainy season absorbs maximum amount of water, due to which the humidity level indoors rises. This promotes the growth of fungus on the surface of it. This directly affects the respiration of human beings.

Wall: The vertical component falls under the secondary priority w.r.t. material choosing which will not get induced with the moisture content outdoors.

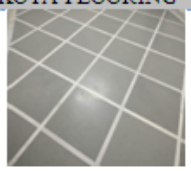
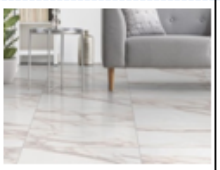
Table 5: Properties of wall materials

WALL				
	COMMON BRICK WALL	LATERITESTONE WALL	GLAZZING WALL	GYPSUM WALL
	 **Figure 5: Brick wall**	 **Figure 6: Laterite wall**	 **Figure 7: Glass wall**	 **Figure 8: Gypsum wall**
Thermal Conductivity W/(mK)	1.2729		1-0.80	0.2527
CLIMATE	WARM & HUMID			
Density kg/m³	2049		2477	623
	Brick wall has layers of cement plaster from both sides. And the layers are coated with finishes, paints etc. the cement coating has tendency to absorb the water. The absorbed water gets accumulated into the porous bricks, which don't get evaporated easily by external radiations.	Laterite stone wall absorbs less amount of water vapour because of its high density. The temperature indoors is not affected due to the any absorbed vapour. The inner surface is coated with lime, which cease the fungal and bacterial growth on the surface.	Glass is a transparent material which is almost used as a wall for differentiating the indoor and outdoor environment. The material is brittle and very dense, which don't absorb humidity and water easily roll through the surface.	Gypsum wall is used to make partition wall and false sealing. In spite of not being an external wall, it gets reacted with humidity in the air due to its less density. It has high tendency to absorb the water, if came in contact with.

WINTER SEASON	Brick walls in winter season acts moreover as an insulator, which don't allow inside heat to go back in the environment. It normally absorbs water vapour because of its nature and cement plaster don't allow it to get evaporated even after the normal range radiations cast on the vertical walls.	In winters the there is no effect of moisture on the wall. The wall just acts as an insulation material, acquiring the radiation throughout the day and radiating in indoor environment at night when temperature drops.	Glass don't absorb any of the water vapour from the air, but in winter when the outside temperature drops, there gets some chances of condensation of water droplets on the surface facing the indoor environment. this causes due to temperature difference, where watervapor gets condenced. This happens due to lack of air circulation in the indoor environment, which may be resonsible for rise of dampness in the space.	In winters, the wall will work as insulator, dur to its porous nature. No adverse effect of humidity will affect the wall.
SUMMER SEASON	Due to the thickness and porosity, the teperature of the wall rises quickly. Inspite of rise in teperature, the fungal growth is not affected because of the finishing layers of cement.	In summers the wall keeps the indoor environment cool throughout the day, bt radiates the heat at night. Thus disrupting the comfort zone.	In summers there is no effect of moisture on the surface of glass due to high radiations.	
RAINY SEASON	In rainy season, the wall absorbs maximum amount of water. Thus the fungal and bacteral grows speedely on wall surfaces of indoor enviroment.	Due to the high density the water don't seep through the surface of the laterite stone wall. So there is no adverse effect on the indoor environment.	In rainy season too, due to difference in temperature, condensation happens on the surface.	In rainy season, if the wall comes in contact with the water, due to seepage or condensation, there are high chances of microbial radialy growing on the surface and even fungus.

Floor: Flooring of the space comes under tertiary precedence with respect to indoor environment handling. The radiation from the sun and humidity or water has tendency to enter into the indoor environment from floor, transferring all the way through falling on outdoor surface land and leak indoors.

Table 6: Properties of flooring materials

FLOORING					
	KOTA FLOORING	CIRAMIC TILE	QUERRY TILE	VINYL CARPET	HARD WOOD
	 Figure 9: Kota floor	 Figure 10: Ceramic Tile	 Figure 11: Query Tile	 Figure 12: Vinyl Carpet	 Figure 13: Hard Wood
Thermal Conductivity W/(mK)	1.5996	3.0229	0.8	0.04	0.1
Density kg/m³	2700	3102	1700	32	960
	Kota stone has a standard thickness of 2.5cm/1inch. Mostly used in hot climates where it acts as insulation against heat transfer, because of its standard thickness and thermal conductivity more than 1.	Ceramic tiles are used as flooring because of its clean look and plain surface. The standard thickness ranges from 6mm, which has waterproof coat over it. The material is porous, thus having tendency to absorb water. The tile don't get easily heated due to due to its high density, but the shiny finish coating acts exactly opposite.	Quarry tiles used as flooring give a textured look, where the surface finish is semi resistant to water, i.e., the humid air may pass through the surface when temperature difference occurs. The low density of the tile allows the heat/humid air trap inside the tile.	Vinyl flooring is used for flooring because of its waterproof nature and easy to clean quality which also gives a fine finish. As it is PVC made, it is waterproof and don't allow water to pass through it. It is least resistant to heat because of its low density as well as its manufactured ingredient.	Wooden tiles give a natural texture to the flooring. It is less dense which acts as an insulation at some extinct. The moisture gets trapped due to its lower density, which might degrade the material after a period of time. The humid air/ heated air might enter into the indoor environment through the joineries which not fully waterproof unless a sealant is used for waterproofing.
	None of the flooring finishes react with the moisture content accept wooden flooring. Wooden flooring can bulge or promote fungal growth on it after a period of time unless it is not maintained properly, or comes in direct contact of water.				
WINTER SEASON	When the temperature falls, the stone gets cold faster, hence there is no adverse effect of the temperature on it.	The ceramic tile too don't shown any reaction as the temperature falls.	Because of the temperature difference between indoor and outdoor, the water may condense on the surface of the floor because of its semi-permeable finish	There is no effect of the humidity because of the plastic ingredient in it.	Wooden flooring shows no effect when there is fall in temperature.

SUMMER SEASON	The flooring will resist the heat from entering, if the heat tries to enter the loadbearing structure, by getting transferred from outdoor ground to indoor space.	Ceramic tile will not transfer heat or show any effect of moisture, in spite of high outdoor temperature.	The tile will exhale humidity absorbed inside it, if its temperature rises.	The flooring will transfer heat into the indoor environment, if the floor/ slab get heated, but not allow water vapour to pass through it. The water may condense on the surface, if there is a large difference between slab's temperature and indoor temperature. If slab gets overheated, in spite of negligible temperature difference, the sheet might come off from the slab surface.	The wood shows no effect, unless it has any moisture content absorbed in it. The moisture may easily pass through the material in indoor environment.
RAINY SEASON	In rainy season, the surface is not affected and no adverse effect of humidity can be seen.	Ceramic tiles don't show any effect in rains because of its water resistant surface.	The tile surface might condense water, due to temperature difference and semi-permeable surface coating.	The vinyl flooring does not show any effect of water on it.	The wood might promote fungal growth because of poor workmanship or not maintained properly.

VIII. CTIVE AND PASSIVE TECHNIQUE FOR DEHUMIDIFICATION.

It is not so easy to discard moisture, as it is a costly affair to do so. The two main techniques for dehumidification are:

8.1 Desiccant Dehumidification

A better indoor environment can be called when it protect people from health hazards and provide comfort and healthy environment indoors. To achieve such conditions, ISO and ASHRAE made some thumb rules which are been followed world-wide.

ASHRAE & CIBSE illustrates a de-humidification as the process of eradicating moisture or an amount of water vapour from the surrounding air. In the figure given, A is the initial point and B is to be achieved. The green line is the path which carries a post cooling process.

A. Refrigeration or cooling

Refrigeration process drops the temperature of a surface below dew-point which allows the humidity or vapour in the air to condense on it.

B. Desiccant

Another method is to expose the humid air to a desiccant, which traps or hold the water vapour in the adjacent air at room temperature. Desiccant has an ability to hold over 100% of its dry weight in vapour.

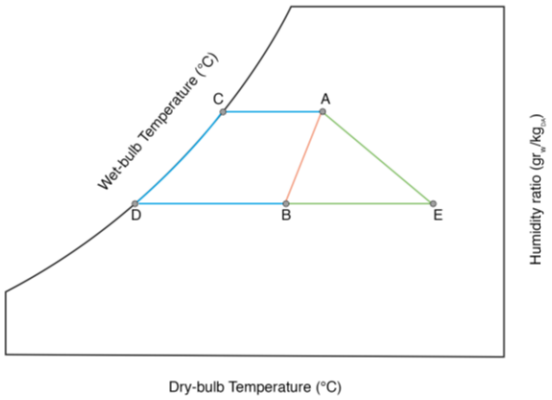


Figure 14: Graph

C. Solid desiccant

Silica gel is one of the solid desiccants which has tendency to hold water and absorb moisture at larger extant. The vapour pressure shifts from immense to minute level; it means there is always a pressure on indoor air from outside.

D. Desiccant wheel

The wheel comprises of a rotor made of corrugated sheet, the desiccant material comprises up-to 80% and remaining 20% is a ceramic fibre which joins the surfaces of the wheel. Lesser the parts, lower is the maintenance. The wheel keeps the cycle of dehumidification in continuity.

E. Liquid desiccant

The behaviour is similar to the solid wheel, but has its own pros and cons, with respect to the requirements needed. Common salt, lithium chloride (LiCl), lithium bromide (LiBr) and calcium chloride (CaCl) are some compounds with nearly zero V.P. hence the moisture gets mixed with the compounds which can also be reversed. Since it too has property of absorbing the moisture as solid does, the resultant heat gets released due to the exothermic reactions.

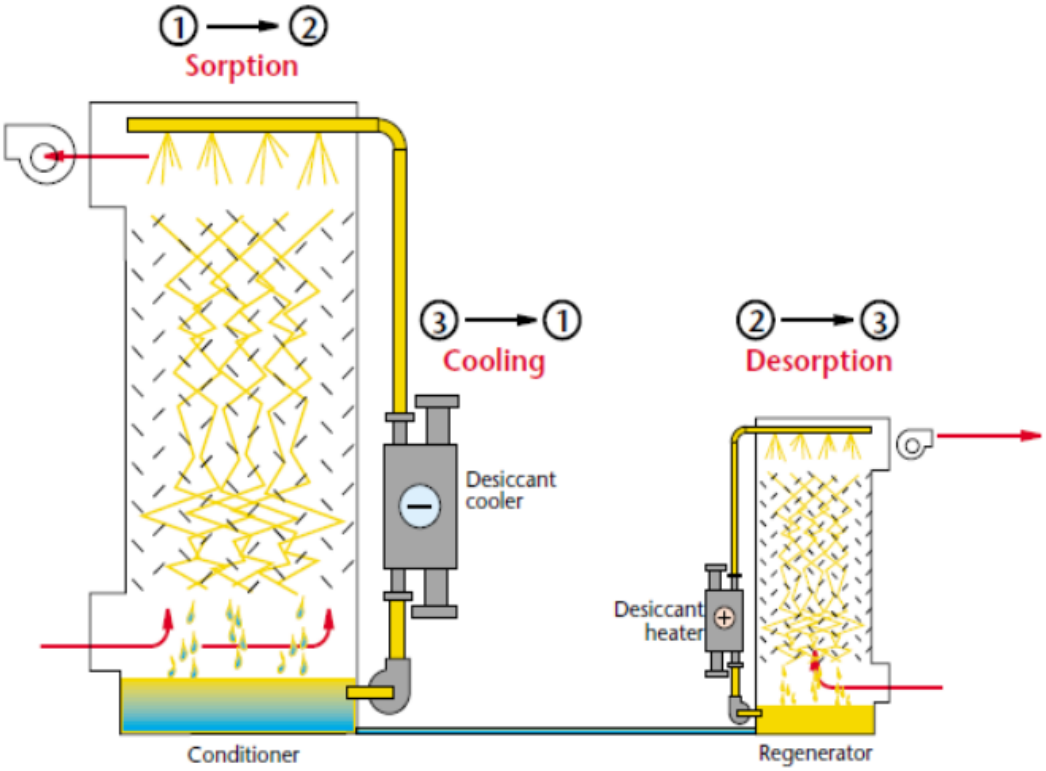


Figure 1: Liquid Spray Tower Diagram

8.2 Liquid Spray Tower

In this process, when the air from outdoor environment flows in indoor space, the liquid desiccant sprayed absorbs the moisture. It is needed to pre cool the desiccant as this process tends to hike the temperature of it. Due to this there is fall in temperature as well as humidity of the air at same time.

IX. TURNING HUMIDITY IN THE AIR, INTO WATER

WATER MAKER: This is a machine which works on the unique fundamental of optimizing the humidity in the air to transform into pure potable water. The machine actually sucks or absorbs the moisture present in the indoor environment, purifies it and adds some mineral, thus making it safe for consumption. The basic cost of the machine is about Rs.4 lakhs. The maintenance of it starts from Rs.3/L with energy usage of 2.2-2.5 KW/day. The machine works suitable in the regions of adequate high humidity between 50-80% having temperature below 40deg. the overall output of water ranges till 110L/day.

Appropriate Condition For The Working Of Machine

Humidity and temperature are the main ingredients to generate water. The machine must be located in well ventilated areas of the room so as to get the best results. The recommended temperature is about 40Deg and humidity level between 40%-100%.

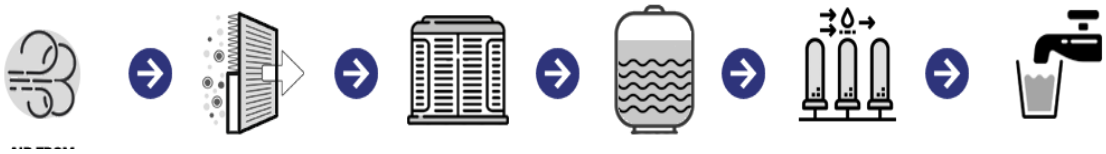


Figure 2: Water Maker Diagram

Life of the Machine

The machine comes with 1 year warranty. For clear working of the machine regular maintenance must be done. When the machine is used in regions with low humidity or dry air, the working of the machine is challenged, as it is not created for low humid regions with hot or cold climate. This might hinder the working of the machine and lower its life.

With proper maintenance of the machine, the life span would last for several years. As the machine have less moving parts, the machine will work to its fullest, if the compressor is regularly serviced.

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