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IMPROVING INDOOR AIR QUALITY USING LOW-EMISSIONMATERIALS

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Abstract

The interior design field faces a technological breakthrough in the development of materials and methods of usage and implementation, which requires great attention for supportive studies The aim of this research is to improve indoor air quality by using lowemission materials with control and rationing the use of contaminant products in residential spaces And because human is the goal of every development and has the right to live in a healthy environment and healthy spaces, and mainly the success of any interior designer in all about taking care of this purpose that depends on the professional control and harnessing the available possibilities to achieve this benefit and prevent pollutants that may affect and cause a threat to human health Therefore it was necessary for professional interior designers and researches the interest to turn to the technological study of new materials and identifying their properties, advantages and disadvantages, characteristics and toxicity, and defining the standards to use these materials so as to be in conformist with the good and healthy environment The expected results of this research are to achieve the major goal of good and practical interior design with low emission using requirements to meet the referenced standards of green labeled materials that are generally widely available in the market, and to develop the other necessary contaminant products and materials that are currently and generally used by controlling and rationing usage of these contamination's that negatively affect the indoor air quality and the human health in residential spaces.

Keywords

Indoor air quality, Low-emission materials, Contaminant products, Residential spaces, Greenlabeled materials

IMPROVING INDOOR AIR QUALITY USING LOW-EMISSION MATERIALS

CONTROL AND RATIONING THE USE OF CONTAMINANT PRODUCTS IN RESIDENTIAL SPACES

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ABSTRACT: *The interior design field faces a technological breakthrough in the development of materials and methods of usage and implementation, which requires great attention for supportive studies The aim of this research is to improve indoor air quality by using low-emission materials with control and rationing the use of contaminant products in residential spaces And because human is the goal of every development and has the right to live in a healthy environment and healthy spaces, and mainly the success of any interior designer in all about taking care of this purpose that depends on the professional control and harnessing the available possibilities to achieve this benefit and prevent pollutants that may affect and cause a threat to human health Therefore it was necessary for professional interior designers and researches the interest to turn to the technological study of new materials and identifying their properties, advantages and disadvantages, characteristics and toxicity, and defining the standards to use these materials so as to be in conformist with the good and healthy environment The expected results of this research are to achieve the major goal of good and practical interior design with low emission using requirements to meet the referenced standards of green labeled materials that are generally widely available in the market, and to develop the other necessary contaminant products and materials that are currently and generally used by controlling and rationing usage of these contamination's that negatively affect the indoor air quality and the human health in residential spaces.*

KEYWORDS: *Indoor air quality, Low-emission materials, Contaminant products, Residential spaces, Green labeled materials*

1. INTRODUCTION

Human is the purpose of all development, and have the right to live in a healthy environment and better pure atmosphere full of beauty, the measure of the success for humans to maintain this purpose depends on what it controls and harnessing the possibilities available to obtain the full benefit of its environment and prevent the spread of contaminants that cause diseases. It has become clear that the problem of pollution is not limited to only the outdoor environment, but also include the interior or (indoor) environment and became a problem after knowing about sick buildings syndrome (SBS) that have become the concern of the World Health Organization experts that described it as a set of health phenomena and symptoms that the symptomatic symptoms causing eye irritation, chest and nose allergy, mental fatigue, dizziness, and some type of chronic headache.

Indoor air pollution has been listed as one of the major environmental pollution factors that cause a significant risk on human health. In accordance with statistics provided by many institute that 68% of interior decoration finishing materials on that we usually use in our projects are off-gas toxic air pollutants, and contain more or less three hundred type of VOC's and other off-gases causing maybe thirty different types of health problems (Wu, 2001).

Although the concerns about potential public health problems due to indoor air pollution which are based on evidences that residents are spending more than 90 % of their time into indoor spaces and about 65% of their time inside their own houses. (http://enhs.umn.edu/current/5103/air/formaldehyde.html, 2018)

The environment in a boundless framework is of concern to all rich and poor societies, developed and backward. They contain the material and moral aspects of these societies, and by maintaining a clean environment that provides a way of life for the human being and the preservation of his humanity. The style of the house and how it is located are influenced to a large extent by the environment, culture and intellectual, economic and political trends of the individual. Each era of the ages, and each environment has its own art. And the direction of interior design to achieve the purposes of benefit does not come out of the scope of art and beauty is achieved both sides, the side of the benefit and the aesthetic side, there is a strong relationship between human and technology, both during the stage of design or stage of implementation. Architecture and interior design require a large degree of technology to achieve and take its final form, which distinguishes its civilization from others.

The environmental issue has become one of the important issues that impose itself on society and perhaps include many concepts, such as the level of well-being, life and technological progress. It is clear that the clean environment depends mainly on the self-ability of the society and the exploitation of natural and human resources available. And technology is one of the most important sources that work to preserve the environment and the development: An internal source stems from the ability to innovate within the community, which is reflected in the capabilities of individuals in different fields of work and the external source works on technology transfer from developed countries in this field to other least developed countries.

The human community faces a some challenges due to the modern scientific and technological revolution that lead to the necessity to effect some radical changes in the patterns of production and management systems, and in the features of daily life in particular. In this context, we find that the field of interior design and furniture fabrication undergoes a technological upheaval represented in the development of materials specification and finishing methods, which requires the development of the fields of accommodation, standardization, codification and subjection when the desire is to apply the bases of this technological upheaval, with the aim of increasing the abilities of the different sectors relevant to the field, and increasing the performance levels as well as trying to reach the modern technology in the means of finishing that serve the environmental conditions and achieve the technological consistence economically, socially and environmentally. The technological development which characterizes this age made a great progress in the provision of some modernized materials including those used as alternatives for the natural woods, natural marble, made from plastic with some additives with the aim of imparting it with more good physical and mechanical features such as the affordability and erosion and friction resistance. Several materials were produced, and each of them has various properties and specifications between the high flexibility such as the compounds made of synthetic rubber to the solidity that is similar to steel such as the epoxy resins, but the used of some of these industrial materials is not relevant to the mild or hot weather, and do not afford the high temperatures or subjection to sun rays because heat decays such materials and this decay results in the emission of sun toxic gases that harm the health of man.

The problem with indoor environmental pollution is even more critical and can result greater damage to human health and affect on economic development because of the recent improvements to living standards using different interior decoration finishing materials that usually content Formaldehyde and other kinds of VOC's pollutants, however, those materials are a must in our work for aesthetic and function reasons but at the end they emit harmful gases that cause some direct or potential health problems.

The scientific development is the engine to the theories of design, the internal design is linked to the future of scientific and technological development as a variable factor with time and has a global and local status together, and is linked to the technique of interior design to help the development or vision of the future inner space. In the interior design must be accompanied by the flow of science and knowledge in various fields and science. The design process has become complex and interconnected among many disciplines. The knowledge that formed the experience of the interior designer is no longer sufficient to find a balance between art and technology.

The interior designer is required to have his designs obtained from different studies based on:

- Social and cultural studies and project economics.
- Conscious studies to benefit from the heritage.
- Study of the functional and flexible arrangement that has best achievements using easy methods.
- Study environment surrounding the elements of space and internal vacuum in particular.

- Probing, identify, research and study the most appropriate methods of clean technology.

Therefore, it was necessary for the researches to turn to the technological study of modern materials and identifying their properties, advantages and disadvantages, and defining its standards to use these modern materials so as to be in conformity with the environment, to achieve the integral organism of good design and developed technology while keeping the environment and public health. Accordingly the user must be protected and therefore we have to find the way of achieving consistence between the environment and the materials used in the interior design and furniture according to the safe standards in a way or another to minimize it danger and impact on human health.

It is now the time to ask, how to apply standards and use the known green labeled materials that exist in the field of interior design and furniture fabrication, and how to find a proper scientific methodology that achieves the technological consistence in the that field. The research strives in a set of hypotheses as follows: the information, specification and data in several fields immensely multiply in such what is calling Scientific Revolution, specially the field of interior design that is deeply related to other sciences.

To achieve the objectives of the research, following the descriptive analytical methodology through the collection of the different data and specifications for some of green labeled materials used in the field especially into the most important in usage as composite and fabricated wooden panels, paints and finishes, adhesives and sealants. Also studying one of the experiments that was made to improve the indoor air quality by accelerating the emissions of the formaldehyde using hot temperatures in the indoor spaces which is calling bake-out technique, but in my study to this experiment, i found that with some additional process to this technique we can bring much better results that is suggested using a process that comes with the bake-out technique and could be more efficient to reduce the existing level of formaldehyde contaminants.

Finally highlighting on the importance of the indoor landscaping based on NASA researchers that are made on some plants and found that they are effective at removing VOC's, formaldehyde, and other off gases from the air that have been linked to negative health effects. NASA researches suggests having at least one plant per 100 square feet / 10 meter square of home or office space. (https://lifehacker.com/this-graphic-shows-the-best-air-cleaning-plants-accord, 2018)

2. THE MAJOR SOURCES OF VOC's AND FORMALDEHYDE EMISSIONS IN OUR HOMES?

Unfortunately, maybe we will find that it is almost in everything, that's why we have to work on it for the sake of human health.

2.1 Wood floor finishes:

Wet commercial, base- and top-coat floor finishes.

- May emit high levels of formaldehyde.
- Emissions decrease 24 hours after application.
- Finishes are not typically available to the consumer, but they can be (re-) applied by commercial floor contractors at residences or factories.

2.2 Pressed-wood and wood-based products:

Pressed-wood (i.e., hardwood plywood, particleboard, and medium-density fiberboard (MDF)) and wood-based products, especially those containing UF resins, may be a significant formaldehyde source.

- Formaldehyde emissions from pressed-wood products have been reduced 80-90% from levels in the 1980's and earlier due to mandatory formaldehyde emission standards in California and national voluntary formaldehyde emission standards, which are described later in this booklet.
- Emissions decrease 6-10 months after initial testing.

2.3 Wallpaper and paints:

- Moderate levels of formaldehyde initially following application.
- Levels formed during the curing process may be higher than after initial application.
- Emissions are sometimes still detectable 1-3 months following application.
- Some paints are now found with low-VOC formulations.

3. LOW-EMISSION MATERIALS REQUIREMENTS IN RESIDENTIAL SPACES:

The Low-Emission Materials requirements of the Indoor airPLUS Construction Specifications address composite wood products, interior paints and finishes, and carpets and many type of adhesives used in the construction of Indoor airPLUS qualified homes. Products meeting the referenced standards are generally widely available in the market. This document is intended to help consultants, interior designers and architects, and contractors, and Raters identify, suggest and locate available compliant labeled products.

3.1 COMPOSITE WOODEN MATERIALS: as the most used material in the carpentry and furniture fabrication.

- **Plywood:**
  - Requirement: Use only hardwood plywood products certified as compliant with Formaldehyde emissions requirements of ANSI/HPVA HP-1-2009; OR CA Airborne Toxics Control Measure (ATCM) to Reduce Formaldehyde Emissions from Composite Wood Products.

  - Standard 1: ANSI/HPVA HP-1-2009
    - Compliant products example: HPVA HP-1 label on products, packaging, and/or spec sheets. The HPVA HP-1 certification label demonstrates compliance below California ATCM for formaldehyde and HUD Title 24 formaldehyde levels.
  - Standard 2: CA Airborne Toxics Control Measure (ATCM) to Reduce Formaldehyde Emissions from Composite Wood Products
    - Compliant products example: Products labeled by manufacturers as "California 93120 Compliant for Formaldehyde" or "California Phase 2 Compliant," as well as "No added formaldehyde" (NAF) or "Ultra low-emitting formaldehyde" (ULEF)
      Any composite wood product that is compliant with the California ATCM for formaldehyde, including products specifically exempted from the CA ATCM such as PS-1 and PS-2 structural panels and No added formaldehyde or Ultra low-emitting formaldehyde products meet the Indoor air PLUS specification.
      Mills that have been identified by a CARB-approved Third Party Certifier as producers of CARB compliant composite wood products:
      List of approved No added formaldehyde (NAF) or Ultra low-emitting formaldehyde (ULEF)
      Note: partners should request confirmation from the manufacturer or supplier that the product lines they are using are indeed compliant.

Fig. 1 Plywood
Reference: Google Search

- **Particleboard and Medium Density Fiberboard (MDF) Products:**

  - Requirement: Use only particleboard and MDF products certified as compliant with the California ATCM to Reduce Formaldehyde Emissions for Composite Wood Products, OR formaldehyde emissions requirements of ANSI A208.1 and A208.2, respectively, OR certified compliant with the ECC Sustainability Standard by the Composite Panel Association (CPA), OR certified as GREENGUARD or GREENGUARD GOLD.
  - Standard 1 : ANSI A208.1-2009 (Particleboard) ANSI A208.2-2009 (MDF)

- Compliant products example: ANSI A208.1 or ANSI A208.2 on products, packaging, and/or spec sheets.
- Note: These standards are also incorporated into other listed programs and labels.

- Standard 2: Eco-Certified Composite (ECC) Sustainability Standard by the Composite Panel Association (CPA) CPA 4-11
  - Compliant products example: Look for ECC label on products, packaging, and/or spec sheets.
  - Companies and facilities that offer "no added formaldehyde" (NAF), ultra-low emission formaldehyde (ULEF).
- Note: Products only labeled as "No added urea formaldehyde" (NAUF) are not addressed by CARB and are not compliant with Indoor airPLUS

Fig. 2 Medium Density Fiberboard (MDF)
Reference: Google Search

Fig. 3 Particleboa
Reference: Google Search

3.2 CABINETRY:

- Requirement: Use Cabinetry made with component materials (plywood, particleboard, MDF) that are certified to comply with the appropriate standards above; OR registered brands or products produced in plants certified under the Kitchen Cabinet Manufacturers Association's (KCMA) Environmental Stewardship Certification Program (ESP 05-12); OR GREENGUARD or GREENGUARD Gold Certification for Cabinetry.

- Standard 1: Cabinet components must comply with the appropriate standard above.
  - Compliant products example: Look for: ANSI A208.1 or ANSI A208.2, OR the ECC label.
- Standard 2: KCMA's Environmental Stewardship Program (ESP 05-12)
  - Compliant products example: Look for the KCMA-ESP label on cabinets (often sink bases), product packaging, and/or spec sheets.
    For a list of KCMA certified manufacturers that produce compliant cabinets.
- Standard 3: GREENGUARD or GREENGUARD Gold Certification for Cabinetry.
  - Compliant products example: For a list of GREENGUARD or GREENGUARD Gold certified cabinetry.

3.3 INTERIOR PAINTS AND COATING FINISHES:

As a must for interior finishing coats for all the indoor surfaces.

- Requirement: At least 90 percent of the interior surface area covered by site-applied paints and coatings shall use low-VOC or no-VOC products certified by one of the following third-party standards or certifications:
- Standard 1: GREENGUARD or GREENGUARD GOLD Certification for Paints and Coatings.

- Compliant products example: Look for GREENGUARD labels on products, packaging, or spec sheets: Search for GREENGUARD and GREENGUARD Gold certified paint and coating products.

- Standard 2: Scientific Certification Systems (SCS) Standard EC- 10.2-2007 or Indoor Advantage Gold.
  - Compliant products example: Look for the Indoor Advantage Gold label on products, packaging, or spec sheets.
- Standard 3: CA Section 01350 (CDPH Standard Method V1.1- 2010).
  - Compliant products example: Look for low-emitting products found in the CHPS database. CA 01350 Certified products.
- Standard 4: Green Seal Standard GS-11.
  - Compliant products example: Look for the Green Seal label on products, packaging, or spec sheets: Green Seal Standard GS -11 products.
- Standard 5: Green Wise and Green Wise Gold products
  - Compliant products example: Look for the Green Wise labels on products, packaging, or spec sheets. Find Green Wise and Green Wise Gold products.
- Standard 6: Master Painters Institute (MPI) Green Performance ® Standards X-Green, GPS-1 or GPS-2.
  - Compliant products example: Look for the MPI labels on products, packaging, or spec sheets.

3.4 ADHESIVES AND SEALANTS:

As a must for materials installation and interior execution and finishing.

- Requirement: (Advisory) While not currently required by Indoor airPLUS, EPA recommends that at least 90 percent of site-applied interior adhesives and sealants be low-VOC or no-VOC products certified by one of the following third-party standards or certifications: A third-party low-emitting product list based on CA Section 01350 (CDPH Standard Method V1.1-2010), OR Green Seal GS-36.
- Standard 1: CA Section 01350 (CDPH Standard Method V1.1- 2010)
  - Compliant products example: CA 01350 Certified products can be found in the Collaborative for High Performance Schools searchable high performance building product database
- Standard 2: Green Seal GS-36.
  - Compliant products example: Green Seal GS-36 Adhesives for Commercial Use.
- Standard 3: GREENGUARD or GREENGUARD Gold Certification.
  - Compliant products example: GREENGUARD or GREENGUARD Gold adhesives and sealants.

All the previous materials has been developed and been approved by many studies to reach the standards of EPA and the US CPSC, organizations and other standardizations as ASHRAE, by using new alternatives for some safe components that was essential to keep almost the same properties of many materials and furniture into their fabrication specially wooden materials, paints and finishes, adhesives and sealant.

4. REDUCING EXISTING VOC's AND FORMALDEHYDE LEVELS

The methods used to reduce VOC's and formaldehyde levels is unique to each situation. The most common and available steps and methods used includes:

4.1 Remove formaldehyde-emitting products from your home

- Directly reduces formaldehyde levels by controlling temperature and humidity in indoor and specially residential spaces.
- Prevents other materials in the area, such as carpet and gypsum board or any other ores from absorbing and then re-emitting these gases.

4.2 Bring large amounts of fresh air into the home

- Increases ventilation by opening doors and windows and by using a mechanical exhaust fan(s) based on correct calculation of CFM to make air in-out to indoor spaces and always maintaining and frequently changing air filters.

Table 1: ASHRAE Ventilation Guidelines
Reference: ASHRAE Standard 62.1-2013: Ventilation for acceptable Air Quality, ASHRAE, Atlanta, 2013.

Facility Type	Estimated Occupancy Persons/90-100m2	Outdoor Air Requirements	
		(CFM/Person)	(L/s/Person)
Bedroom/Living room	10	11	5.5

Table 2: Typical Air Changes Per hour Table
Reference: https://www.contractingbusiness.com

Residential Facility Type	Estimated Number of Indoor Air Changing / hour
Bedrooms	5-6
Bathrooms	6-7
Family Living rooms	6-8
Kitchens	7-8
Laundry	8-9
Basements	3-4

4.3 Seal the surfaces of formaldehyde-emitting products that are not already laminated or coated

- Use a vapor barrier, such as some paints, varnishes, or a layer of vinyl or polyurethane- like materials
- Seal completely with a material that does not contain formaldehyde
- Many paints and coatings emit other VOCs when curing; therefore, ventilate the area well during and after treatment

4.4 Install “manufactured-home,” pressed-wood products

- Made with composites meeting the Ultra-Low Emission Formaldehyde (ULEF) or No Added Formaldehyde (NAF) requirements; formaldehyde emission from NAF is less affected by increased temperature and humidity than ULEF. 1

5. REDUCING EXPOSURE TO HIGH LEVEL OF VOC's AND FORMALDEHYDE

5.1 Installing artificial or composite wood floors or finishes that are not “acid-cured”, which is a type of finish that is formaldehyde-based.

5.2 Installing pressed-wood or cabinetry and furniture products, using such as particleboard, MDF, or hardwood plywood, for all interior decoration in homes finishing that are labeled or stamped in

compliance with the American National Standards Institute (ANSI) or California Air Resources Board Air Toxics Control Measure (CARB ACTM) criteria.

- Particleboard should conform to ANSI A208.1-2009 (label designated "-F18" or "-F09" (Grade D2) or "-F20," "-F18", or "-F09" (Grade D3)) or the CARB ACTM.
- MDF should conform to ANSI A208.2-2009 (label designated with "-F21" or "-F11" for MDF > 8 mm thickness; "-F21"or "-F13" for MDF ≤ 8 mm thickness) or the CARB ACTM.
- Hardwood plywood should conform to ANSI/HPVA HP-1-1994 or the CARB ACTM.
- The Composite Panel Association (CPA) or Hardwood, Plywood, and Veneer Association (HPVA) stamps (examples below) also certify that products conform to the ANSI standards. These standards all specify lower formaldehyde emission levels.

5.3 Installing furniture or cabinets that contain a high percentage of panel surface and edges that are laminated or coated.

- Sometime laminated coats block these emission from the regular surface of the pressed-wood or plywood, but usually you will find the adhesive used to bond the laminated coat to the pressed-wood contain already VOC's.

5.4 Installing alternative products not fabricated with urea-formaldehyde glues or adhesives.

5.5 Installing "manufactured-home", pressed-wood products bonded with a phenol-formaldehyde resin system or other pressed-wood products made with composites meeting the NSF/ANSI requirements.

5.6 Installing insulation that is not based on UF foam.

5.7 Avoiding high household temperatures to exceed more than 30℃.

5.8 Maintaining humidity in the house at 40-50% by:

- Installing or using exhaust fans where moisture is generated
- Using dehumidifiers in humid climates.
- Reducing moisture in crawlspaces or basements.
- Not using humidifiers or other products to add moisture to already humid air.

Table 3: Formaldehyde Concentration in Air
Reference: https://www.ncbi.nlm.nih.gov/books/NBK138711/

Temperature ℃+/-1℃	Relative Humidity % +/- 5%	Formaldehyde Concentration PPM	% of Maximum Value
30	70	0.36	100
25	70	0.29	81
30	50	0.28	78
30	30	0.23	64
25	50	0.17	47
25	30	0.14	39
20	70	0.12	33
20	50	0.09	25
20	30	0.07	19

5.9 Washing durable-press fabrics before use and not choosing clothing and fabrics that are likely to contain formaldehyde, such as rayon, blended cotton, corduroy, wrinkle-resistant 100% cotton, shrink-proof wool, and heavy stiff fabrics.

5.10 Bake-out of buildings is believed to have a potential to reduce indoor air pollution caused by VOCs and formaldehyde emitted from building materials although controversial discussions have been suggested.

6. CLARIFYING THE EFFECTIVENESS OF BAKE-OUT

The variation of VOCs and formaldehyde emission rate from building material were investigated in residential housing units with passive sampling methods. For about during a month, measurements of emission rate are carried out on various building materials such as wood based materials and paper based materials installed in real buildings at which bake-out was conducted. According to the results, the toluene emission rate from wood based materials clearly decreased with only ventilated conditions during bake-out.

Bake-out of buildings is believed to have a potential to reduce indoor air pollution caused by VOCs and formaldehyde emitted from building materials although controversial discussions have been suggested. To clarify the effectiveness of bake-out, in this study, the variation of VOCs and formaldehyde emission rate from building material were investigated in residential housing units with passive sampling methods. For about a month, measurements of emission rate are carried out on various building materials such as wood based materials and paper based materials installed in real buildings at which bake-out was conducted. According to the results, the toluene emission rate from wood based materials clearly decreased with only ventilated conditions during bake-out. However, the toluene emission rate from wall paper decreased regardless to the ventilation condition. Compared to toluene emission rate, we couldn't observe a clear reduction of formaldehyde emission rate from most of building materials. (Dong-Hwa-2007)

7. FLUSH-OUT

Also, we can call it (AIR FLUSH). An air flush or building flush is a technique whereby air is forced through a building after construction and prior to occupancy in order to remove or reduce pollutants, such as VOCs and particulate matter, inadvertently introduced indoors during construction. Air flushing improves indoor air quality by limiting the exposure to an intense contamination period. A building air flush is performed while maintaining an indoor temperature of at least 15 °C [59 °F] and relative humidity below 60%, at one of the following volumes:

A total air volume of 4,266 m^3 of outdoor air per m^2 of floor area [14,000 ft^3 per ft^2 of floor area] prior to occupancy. A total air volume of 1,066 m^3 of outdoor air per m^2 of floor area [3,500 ft^3 per ft^2 of floor area] prior to occupancy, followed by a second flush of 3,200 m^3 of outdoor air per m^2 of floor area [10,500 ft^3 per ft^2 of floor area] post-occupancy. While the post-occupancy flush is taking place, the ventilation system must provide at least 0.1 m^3 per minute of outdoor air per m^2 of floor area [0.3 CFM outdoor air per ft^2 of floor area] at all times. (https://standard.wellcertified.com/air/air-flush, 2018).

My idea is to make a flush out to the indoor spaces by flushing out the calculated amount of CFM in those spaces and according to the mechanical machines that will supply and exhaust (vacuum) the same amount of CFM in successor to the bake-out phases and with keeping on high temperature 35-40°C, that will be instead of the regular ventilation they was making before, the flush out will get rid of all the off-gases and will not let the materials to reabsorb them or even a part of them again when room temperature is cooling down.

8. INDOOR AIR CLEANING PLANTS

A healthy home environment is vital to a person's well-being and houseplants contribute to it more than you might think.

Dr. B. C. Wolverton led the study about 27 years ago and according to it's results, The Florist's Mum and Peace Lily are the best choices for the job. NASA also recommended to have at least one plant per 100 square feet - 10 square meter and although this research is quite old, it is still regarded by many as the most comprehensive and accurate to date. nasa.gov. And there is other plants as Philodendron (Chlorophytum), Spiderwort (Tradescantia), and Golden Pothos (Epipremnum Pinnatum).

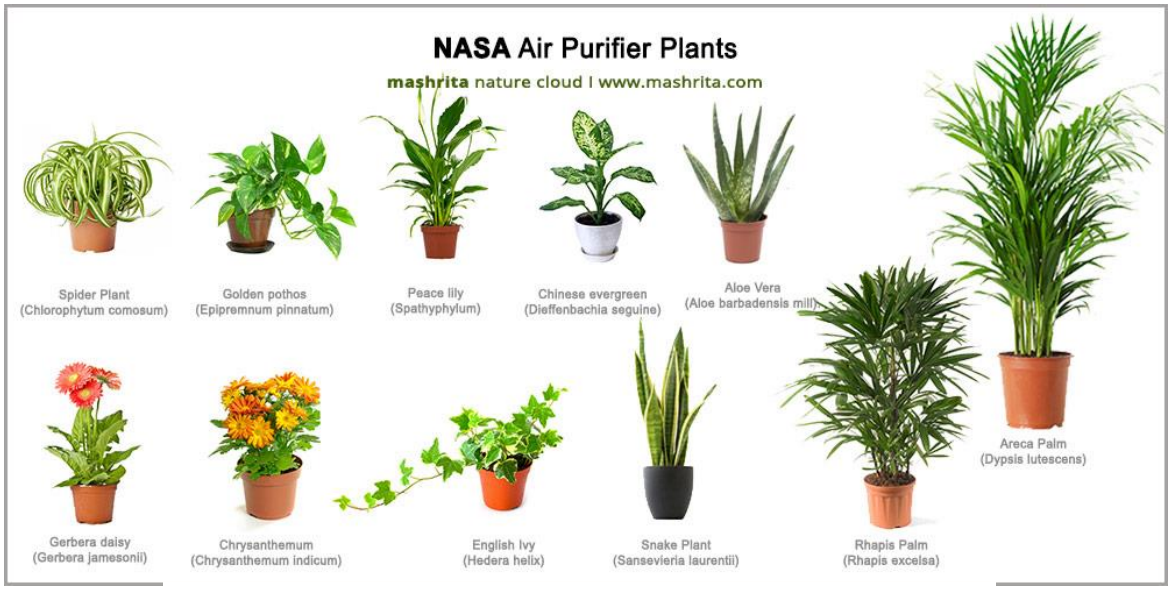

Fig. 4 Air Purifier Plants
Reference: www.mashrita.com/29-best-air-purifying-plants-nasa-

9. CONCLUSIONS

After studying the technology of modern materials used in interior design and furniture fabrication, and also after working on the study of finding available materials with low emission using requirements to meet the referenced standards of green labeled materials that are generally widely available in the market but not well known yet and just need to be well introduced, also working on finding the solutions to reduce and limit with developing, and controlling the other necessary contaminant products and materials that are currently and generally used by controlling and rationing usage of these contamination's that negatively affect the indoor air quality and the human health in residential spaces.

- Housing has become one of the sources of pollution as a result of methods and modern materials in the construction and the contents of industrial raw materials and devices adversely affect human health.
- The results of studies recently approved by the US-EPA indicate that the concentration level of most indoor pollutants is often about twice as high as five times the concentration levels in the outdoor.
- One of the most important sources of pollution is the internal air of the house, which deals with chemicals, high toxic materials and modern floors of carpets and others, which includes the substance pvc poisonous and paints and adhesives that contain materials with toxic fumes and also insulation and adhesives materials, where the installation of bitumen or glass wool They are both toxic, also wallpaper especially the washable plastic species, containing toxic vinyl foam, which make all of these surrounding materials that adversely affects the skin and respiratory tract of humans, especially children and the elderly.
- It is preferable to use paints, aqueous dyes and natural adhesives instead of organic solvents, so that the solvents used in divorce do not affect the public health and environment.
- The presence of decorative plants that absorb carbon monoxide, formaldehyde and volatile organic compounds from the internal air of the residential places.
- Of the very important standards that must be taken into account when selecting the raw materials used in interior design and furniture:
  - Emission of gases and toxic materials.
  - Soft dust release during manufacturing and installation.
  - Radiation activity.

- Period of use and possibility of recycling.
- Good ventilation to improve the IAQ of all the kinds of indoor spaces and according to the codes and standards and especially for the new and renovated apartment.

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