

The Assessment of Indoor Ambient Air Quality of Houses in Turkey

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Abstract : *In Anatolia, traditional Turkish houses have some features such as being materials obtained from local sources, planning according to climate and geographical characteristics, using renewable materials, producing special solutions in terms of heating and cooling. According to the regions where they are built, they are seen as a common feature in almost all of them, although they have different characteristics in terms of use of materials and architecture. These properties make up indoor air quality of these houses. In particular, materials used in the construction of space and space elements, planning features of buildings, viruses and bacteria, various dead or living microorganisms, etc. Affect the indoor air quality negatively and causes sick building syndromes. Within the scope of this study, the evaluation of the indoor air quality of the traditional houses built in Anatolia was made. The houses constructed with different planning features by using different materials in different regions were examined in terms of indoor air quality characteristics.*

Keywords: *Anatolian houses, interior air quality, sick building syndrome, sustainability, traditional Turkish houses*

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I. Introduction

Being the reason for existence of world and the most important vital substance for all living creatures on earth, the air is defined as a mixture of colorless and odorless gases [1]. It is impossible for a human being to survive more than a few minutes without breathing while being able to survive for a certain period of time without eating or drinking water. Today, most people spend their daily lives indoors. For this reason, the air quality of the spaces is crucial.

In line with the requirements of the modern world, people have begun to produce more comfortable buildings with the construction technology in terms of physiological, psychological, social and cultural aspects. The comfortable spaces which can be easily cleaned and do not require maintenance and repair and where the thermal comfort is provided have been designed and built. However it is not possible to say that the indoor air quality of these spaces is high. Due to reasons such as the materials used, methods of application, technology etc., and today the internal air quality of indoor spaces have turn into an unhealthy environment and threaten the human health.

When the traditional buildings in Turkey are examined, it is possible to say that people lived in healthier places because of traditional building technology, materials used and planning features. Within the scope of this study, it has been aimed to examine the traditional Turkish residence in terms of indoor air quality. For this purpose, firstly the concept of indoor air quality has been analyzed and later on the assessment of these dwellings has been done from the perspective of indoor air quality according to the definition and the region – based planning and construction characteristics of traditional Turkish houses.

II. Importance Of Study

Other than some exceptional situations, the scientific studies conducted have introduced that the buildings in Turkey conform to ecologically sustainability criteria [2, 3, 4, 5, 6, 7, 8, 9, 10]. The indoor ambient air quality is also contained among the sustainability criteria. Even though there are scientific studies in which the sustainability and ecological aspects of traditional Turkish houses have been analyzed, the internal ambient air quality – oriented studies contained among the criteria of sustainability are quite few. For this reason, it shall establish a resource for the indoor air quality - oriented studies in terms of indoor air quality at the traditional residential architecture in Turkey.

III. Method Of Research

In the scope of study, the evaluation of general characteristics of residences situated across the Anatolia has been done in consideration of the samples of traditional properties of Turkish house remained within the current boundaries of Turkey among those ones seen in Anatolia, Balkans and Caucasus. Firstly, the topic – related academic references have been studied in detail and the topic – related definitions have been defined and planning and spatial features of a traditional Turkish house have been discussed in general; the evaluation of houses has been made in terms of the factors affecting the indoor environment quality thereof and finally a discussion environment regarding the compliance of the houses from the perspective of their indoor environment quality has been made up.

IV. Interior Air Quality

According to the studies conducted by American Environmental Protection Agency (EPA), the indoor air pollutants can be approximately 5-100 times higher than those making up the fresh air [11]. While the effects of air pollution have been known especially since the Industrial Revolution, the indoor ambient air pollution is a new concept; has appeared approximately 1970s [12].

Ambient air quality is a concept related to the purity of the air breathed in the spaces where the living things live [13]. The fresh air is defined as the air not containing harmful and pollutant substances above the levels specified in the regulations and not making up discomfort on the human being [14]. There are approximately 78% nitrogen, 21% oxygen and 1% other gases, such as dust, water vapor, in fresh air [15]. However, the purity of indoor ambient air quality is being discussed in the spaces such as the houses, bureaus, schools, hospitals that we have experienced in recent two centuries. Based on the regulations and standards issued in various countries, the studies regarding the indoor ambient air quality have been conducted. For example, in Turkey, while "Air Quality Assessment and Management Regulation" (Official Gazette Dated 06 June 2008 / 26898) provides the topic – related criteria, ASHRAE Standards 55-62 and 99 and the Standard numbered EN 15251 address the indoor ambient air quality in a broader extent.

There are many gases in the composition of air. The air consists of 21% oxygen, 78% nitrogen, 1% argon, 0.03% CO₂, hydrogen, neon, krypton, helium, ozone and xenon and volatile organic compounds with varying amounts of water vapor and continuous atmospheric pollutants [16, 12].

In the United States, "Clean Air Act" has been effectuated in 1971 and six air pollutants (criteria air pollutants) have been identified. These substances are defined as ozone, particle matter, sulfur dioxide, nitrogen dioxide, carbon monoxide, lead and 189 toxic or hazardous air pollutants [17]. These air pollutants cause acute diseases such as vomiting as well as chronic diseases such as cancer, neurological diseases, reproductive and respiratory diseases.

The factors leading to indoor ambient air pollution are the fuels used for cooking, heating, water heating and the fumes generated during cooking and cigarette smoke, nitrogen acids and the materials used in the building construction and interior decoration and the insulation materials and the protective materials (varnish, paint and varnish etc.) furniture polish and paints and cleaning materials and personal care products, pesticides, pets, mineral fibers (asbestos, man – made mineral fibers (MMMF), textile, electrical – thermal insulation materials), radon 99, formaldehyde, solvents polychlorinated biphenyls, nutritional powders, ionizing radiation and air conditioning devices. The organisms such as molds, fungi, bacteria (especially Legionella bacteria) and cigarette smoke, dust and mineral fibers spread in the air by the influence of artificial and natural air sources [18, 19].

According to European Air Quality Guidelines of World Health Organization, the indoor ambient temperature is required to be 19 – 23 °C and the relative humidity 40-60% and the air flow rate 0.1 m / sec for the indoor ambient air quality to be suitable for the human health. Higher indoor humidity higher than 70% increases the risk of mold formation and causes the air flow in the room to exceed 0.3 m / s results in a 1 °C decrease in the air temperature (World, WHO Air Quality Guidelines for Europe, 1987).

The indoor air quality being below the specified standard level causes a "Patient Building Syndrome". The patient building syndrome is defined as the symptoms that occur while the patient is living in such building but disappear when moved away from such environment. The main symptoms are burning in the eyes, watering, nasal obstruction and discharge, sneezing, dryness in the throat, lethargy, headache and asthma. It is known that the symptoms of patient building syndrome are caused by molds and fungi (such as *Stachybotrys chartarum*) [20, 21].

NO₂ results in from the smoke coming out of the ovens used for cooking and heating and cigarette smoke etc. While NO₂ causes various acute disorders, the mineral fibers lead to various tumors. Radon gas increases in the interior due to various reasons (sewage pipes, sewage pump, etc.) increase the risk of lung cancer [22].

In particular, the formaldehyde and volatile organic compounds (benzene, toluene, chloroform, o-xylene, ethyl benzene, styrene, carbon tetrachloride) used in the materials that make up furniture and indoor space components increase the risk of cancer and cause a great deal of acute discomfort [23].

Especially, the volatile organic compounds are derived from the indoor spatial paints {aliphatic hydrocarbons (n-hexane, n-heptanes) and aromatic hydrocarbons (toluene), methyl chloride, propylene dichloride, alcohols, ketenes, esters, ethers and the adhesives (hexane, heptanes, alcohols, amines, ketenes, ethers) and flooring and fabrics (aromatic hydrocarbons, halogenated hydrocarbons, aldehydes, ethers and esters) and construction materials (aliphatic hydrocarbons (n-decane, n-dodecane) and aromatic hydrocarbons, halogenated hydrocarbons, aldehydes, ketenes, ethers, ketenes, esters)[23].

As it would be understood; the organic chemicals are found in the structure of paints, varnishes, adhesives and construction materials. The studies have also shown that the volatile organic compounds are often come across in the indoor air of the spaces where these materials and products are used [23, 24]. And the most important source of indoor volatile organic compounds is the vehicle traffic in the outdoor environment.

And the formaldehyde originating from the materials used making the interior decoration and furniture is the most commonly found aldehydes in the environment. As for the formaldehyde originating from the structure of the materials used making indoor spatial decoration and furniture is the most common aldehydes found in the environment. Although the formaldehydes are volatile compounds, they are examined individually since they cannot be determined by the methods used in the analysis of volatile organic compounds [23,25]. It is a pungent and colorless gas at the normal room ambient temperature. It is found in especially in the resins, adhesives and upholstery and insulation materials used in the construction of laminated parquet, plywood and kitchen and bathroom countertops. The researches accomplished have shown that the indoor ambient temperature has increased from 23 °C to 40 °C and the formaldehyde exposure factor has enhanced by 5.2 times due to use of these substances [26]. What a pity; that today the interior spaces are being built with utilization of these materials. Therefore, it is evident that the spaces we live in adversely affect our health.

The sources of pollution originating from interior decoration and use of furniture are respectively [27];

- Humidity
- Wooden furniture
- Upholster materials
- Humidifiers
- Insecticides
- Paint products
- Carpets and upholstery
- Parquet and polished wood
- Fireplace, oven, stove, chimney
- Smoke
- Pipes
- Radon gas
- Air Conditioning
- Insulation materials

Today, the pollutant source control of indoor ambient air quality is being likely to be ensured by the methods of cleaning pollutants found in the air and the reduction of pollutant concentrations found in the indoor ambient air using the lower concentration outdoor air. Natural ventilation is particularly important in the spaces; ensuring the spatial ventilation with artificial ventilation systems is an important method. Also the adjustment of humidity inside the space according to the activities and the usage of such space affect the indoor ambient air quality positively. However, the most important issue in ensuring the indoor ambient air quality is that the planning is realized in consideration of indoor ambient air quality as well as needs such as aesthetics, fashion, ergonomics and comfort in the design and construction of spaces.

With the studies initiated on the field of architectural biology in recent years, the structural compliance of the buildings to the human health has been conducted and a significant part of these studies consists of the indoor ambient air quality researches. Structural Biology covers the effects of structures on the environment and human health. Structural biology is the discipline of holistic relations between human and the structured environment. It is a branch of science that researches into the effects of indoor spaces and environments on the human health. Conceptually, in practice of structural biology based on 25 basic rules, the points like the natural structural materials and acoustic insulation and human health and psychological harmony – oriented indoor spatial climate and also energy and water cycles and geological suitability of the construction site are taken into consideration [28].

In addition to the architectural and interior architecture, the structural biology is also applied in form of modification and improvement of its aspects affecting the human health by being measured with a bioclimatic

structural analysis (BSA) of current buildings. And the factors affecting the human health from the perspective structural biology are specified as follows;

- Building materials and building design
- Furniture
- Electrical installation
- Paints and varnishes
- Floor veneers
- Electronic household appliances
- Construction and insulation materials
- Air conditioning and heating systems [28, 29].

V. Traditional Turkish House

The traditional Turkish house has been briefly defined by Eldem [30] as follows:

The traditional Turkish house is a type of residence built within the territories situated in Tracia, Anatolia and Caucasia within the boundaries of the former Ottoman Empire which has ruled more or less 500 years. Kuban [31] describes the traditional Turkish house as a type of residence that shows the shape and plan characteristics of a traditional conforming to the Turkish family life culture and customs and has met the requirements of Turkish people for centuries.

Kucukerman [32] states that the form and usage characteristics of the room that shapes the Turkish house have originated from the nomadic tents. As the traditional Turkish house was shaped according to the lifestyle and culture, even though the general planning features are similar to each other, particularly they show differences according to the regions in terms of material usage and construction technique. The distinct material and construction form has also affected the planning of the dwellings.

5.1. General Characteristics of Traditional Turkish Houses

The climate, geographical features, material selection and construction techniques have been influential in shaping the traditional Turkish house and also affected its planning. Bektas [33] describes the formation principles of the traditional Turkish house have been classified as;

1. Suitability to living, nature and environmental conditions
2. Realism, rationalism
3. Solution from internal to external
4. Internal-external compatibility
5. Attitudinal

When the traditional houses are examined in Anatolia and Tracia; Eldem [34] has sorted Turkish house as Black Sea house, North Anatolian house, Marmara region house, Istanbul house, Aegean and Western Anatolian house, Eastern Anatolian house, Southeastern Anatolia house and Diyarbakir house. The divergence of these houses is rather than their configuration principles, due to diversity of regional features and change of building materials used. No matter what region the houses were made, as the houses are built in compliance to the topography, another house does not hamper its scenery and wind (Fig.1).



Fig.1. Traditional Turkish Houses in Anatolia According To the Regions.

Plan types show the same characteristics among themselves. According to Eldem [34], the houses are examined in four plan types: plan type without sofa, plan type with outer sofa, plan type with inner sofa and plan type with central sofa (Fig.2).

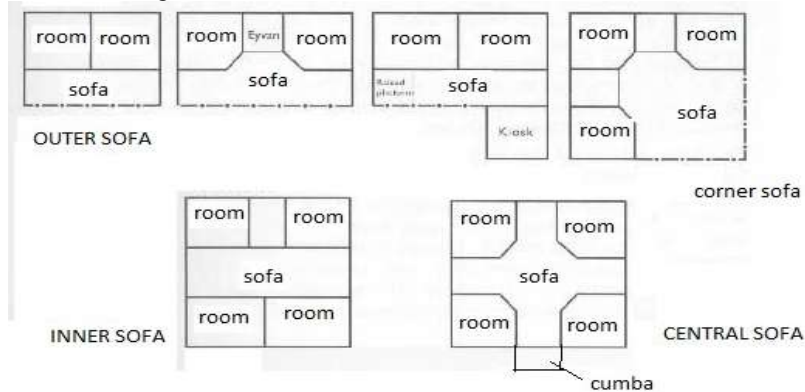


Fig.2. Plan Types of Traditional Turkish Houses [30].

The “sofa” is a circulation and living space. While the plan type with outer sofa is seen in the regions where the climate is hot and temperate and plan type with courtyard-without sofa in the regions with hot – climate zones; the plan types with inner and central sofa have been applied in the cold – climate regions were applied. Especially the close resolution of the rooms stayed away from the climatic effects due to protected structure of the plan type with medium sofa has allowed the plan to become regular. As for the courtyard, as it contains also water, plant and tree flora, it offers a comfortable living space for people from many aspects such as climate and shadow. The stairs of houses that often have more than one story in many regions are also important. While the stairs are in the outdoor at the external front of the house with outdoor sofa, it is in the center of the houses with internal and medium – sofa. Closing the stairs with doors also helps to provide thermal comfort in winter. The closure of the stairs with doors also helps ensuring the thermal comfort in winter months. The spaces such as kitchen, toilet, bathroom and stable are either outside the house or at the ground floor.

And the rooms are usually open to the courtyard or sofa and every room is multifunctional. A room is equipped so as to allow many functions such as either sleeping, or eating or washing to be done at the same time. There is an oven at every room and this oven serves as both cooking and heating tasks. There is a cone to suck the smoke over the oven. The height of the place where the fire is made is 25 – 30 cm higher than the floor. Big woods were not burned at these ovens as with the fireplaces. Starting from the 19th century, the stoves have taken the place of oven in Anatolia. The surfaces of these stoves are either plastered with a special mortar or covered with tiles (Fig.3).



Fig.3. Room Interior of Traditional Turkish House [35].

The windows found at the high – ceilinged room are double – winged which open with horizontal and vertical sliding or vertically, wooden veneer and top windows. These windows have been made in enough numbers and sizes for the rooms and sofas to be both illuminated and ventilated. The curtains used at the doors have provided the privacy and room temperature to be maintained.

5.2. Turkish House Formation and Material Usage by Regions

Climate and geographical conditions, precipitation and geological conditions of the regions have affected the design of Turkish house. While the shape of roof is being shaped in compliance to the rainfall at the locations where the precipitation conditions are excessive; flat terraces have been built at locations possessing a hot climate. In the cold regions, the roofs, walls, windows and doors were made more resistant to climatic conditions. Moreover the topography has also affected the shape and story structure of the houses. Even though not a big difference is seen in terms of climate, material used and the plan between the houses built up on steep slopes in the Black sea Region and those built on the plains in the Southern and Central Anatolia, they differ due to topographic factors. Whatever region the houses are situated in, the ground floor is closed to the street. The upper floors of the houses are planned so that the neighboring house air and view is not interrupted. For example, Mardin houses have been built so as to look at the south and southwest directions in form of slope – compliance terrace houses. The narrow streets are a precaution against the climate and the sun. However, they provide aeration. The iwan (a vaulted room with one side open to a court) and porticos are the living areas providing connection to indoor places in clear daylight in the houses having a plan type with a courtyard. These spaces are climate – protected areas and provide clean air distribution to the indoor spaces.

Other than climate and topography, the use of materials also changes according to the regions and it contributes characteristic feature to the Turkish house. While wood – weighed material is used at the houses of Black Sea, North West Anatolia and Istanbul which have the rainy climate zone, the stone material is mainly used in Eastern and Southeastern Anatolia where stone material is abundant. While the houses were built in carcass system upon use of wooden materials, the masonry stone houses have been built in the zones where stone was abundant. In stone houses, windows have been kept smaller according to the principles of masonry construction. For example, in Southeastern Anatolia houses, the rubble stone wall provides the necessary heat isolation because of great difference in temperature between daytime and at night and natural ventilation at night [36].

As for the regions without forest and stone, the building material used has been adobe. The adobe has been made from the lute in the Eastern and Central Anatolia and the houses with small Windows have been built in accordance with the masonry construction principles at the low-rise buildings.

The use of adobe as building material dates back to first human. In addition, the adobe is a healthy material; it collects and stores the heat in the wall and provides sound insulation and is fire resistant. The adobe walls are humidity, heat and wind – sensitive. Sudden changes in air temperature accelerate the deterioration of the material due to salt crystallization. Because of this, abrasion has happened at the foundations of adobe – walled houses. If the adobe is protected against water, it is a long-lasting construction material [37].

In the houses of Black Sea, Marmara, North West Anatolia and Black Sea regions where the wood and masonry have been used together, a construction system called "half-timber" has been used. In this system, the space between the wooden frame of houses filled with adobe, stone and brick have been built. In these structures, the walls have been either plastered internally and externally or sometimes the outer front has been left without plaster and some other times, it has been covered with wood as well.

Although the floors and ceilings were generally covered with wood veneer and some houses are covered with earth tiles called as "lime". Again, the floors of some houses are compacted soil. The inner and outer walls are usually lime whitewashed or plastered with "Bagdadi plaster" (plaster applied on wooden wall by adding an additive material such as straw into the mixture of lime and gypsum). Wooden joining techniques have been used for elements such as doors, windows and furniture that make up the building, usually no glue has been used in the connections and nails or dry joining technique have been applied.

VI. Evaluation Of Traditional Turkish House In Terms Of Indoor Ambient Air Quality

In this study, the assessment of the indoor ambient air quality of the traditional Turkish house has been made according to the following titles of pollutant sources affecting the indoor ambient air quality mentioned in the relevant section:

- Humidity
- Use of wood materials
- Flooring materials and carpet use
- Paint products and use of varnish
- Flooring, wall and ceiling veneers
- Smoke, heating devices and air conditioning

- Pipes and fittings
- Radon gas

6.1. Humidity

In the traditional Turkish house, the anti – humidity formation methods have been applied in terms of both planning and use of materials. The roofs where climate - compliance appropriate plan type and structure technique have been applied have been shaped up according to the climate and rainfall. The sloped roofs have been made as a cold roof and the ventilation between the roofs has been provided. The construction materials are local and physically and chemically suitable for the natural environment in which the house was built. The materials have been used in their natural state. The lime mortar plaster used on the interior and exterior walls or the Baghdadi plaster on the walls provides the moisture balance and allows the wall to breathe allowing the interior air to be constantly refreshed. Also the interior decoration materials (wood, textile, paint, etc.) are natural substances, thus balancing the humidity inside the interior space.

6.2. Use of Wooden Material

The wooden material used in the traditional Turkish house, both in the construction and in the interior decoration of the house is natural and solid wood; a natural preservative material obtained from a mixture of linseed oil, ceruse, red lead, pigment, naphtha and siccative materials have been used to protect the wood from physical effects. As for today, solvent – based paints, polishes and varnishes are used for the protection of the wood used as the construction material. As for the furniture, the wood has been preserved with this type of paint or shellac paint and often the solid wood has been left in its natural state. In addition, the wood improving humidity control in the indoor environment is a material suitable for the application of the framework system. In the bearing structure of the building, fir and yellow pine timber have been used and yellow pine timber inside the internal space. These tree species are resistant to climatic conditions and produce a good nail holding timber with smooth fiber structure [38].

6.3. Upholstery Materials and Carpet Usage

Upholstery has been used in the cushions on divans in the rooms and dwelling rooms. The inside of the cushions is filled with cotton, wool and wool waste and covered with appropriate cotton and wool textiles according to the localities. Every year, the inner filling materials of the cushions are removed, washed, dried and embossed and the cushion covers used to be cleaned and then the cushion were sewed again. The same method was used for the quilts and mattresses as well. Therefore, the formation of mold, fungus and bacteria adversely affecting the indoor ambient air quality was prevented. The carpets used on the ground used to be mostly made of wool yarn, the kilims used to be woven from cotton yarn and the curtains used to be made of cotton fabric or natural flaxen. Therefore, there was no chemical substance in the upholstery and carpet structures [38].

6.4. Paint Products and Varnish Usage

For the coloring and protection of the wood used in the indoor spatial decoration, as stated previously, a natural preservative material obtained from a mixture of linseed oil, ceruse, red lead, pigment, naphtha and siccative materials have been used. In the indoor space, also coloring has been made with natural stains on the lime whitewash and Baghdadi plaster. For example, the navy blue color was obtained from lapis lazuli stone, the blue color was derived from indigo, the iron color was obtained from the tile, while the yellow color was obtained from the zarnich and the lahur indigo, the white color was obtained from basic lead carbonate and chalk, the black color and the gray color were obtained from smut and the interiors were colored with these colors [39].

In addition, the veneers on the ceilings, facade and interior walls, wooden window shutters have been colored with ocher and protected. The ocher is a mixed paint made of linseed oil, yellow oxide, naphtha, red ocher. This paint has a characteristic that protects the house from cold, rain and snow in winter and protects it from pests in summer. At the same time, as it does not hamper the air permeability feature of the wood being the construction material, it also ensures the natural air circulation inside the indoor space as well [40].

6.5. Flooring, Wall and Ceiling Veneers

The floors are covered with compressed earth, terracotta tile and natural stone on the ground floor and natural veneer on the upper floors. This unpainted, washable flooring method creates a quite healthy indoor space. The floor being directly soil is more common in the Central and Southeastern Anatolia. However, the soil is quickly deteriorated in these houses and the dusts are mixed into the air. Therefore; the floor often entails the soil to be compacted by being beaten with a mallet. This soil used to create polished layer upon being painted white with lime formed [4].

As stated earlier, the wall covering is either lime whitewash or Baghdadi plaster in the indoor space. For example; following the preliminary plaster with mud mortar on the outer and inner walls at Safranbolu houses, it is re-plastered with a mortar obtained by mixing 15 / 20 day – kept waiting quenched lime with plaster's hair (linen). No sand is added to this plaster. Even the paint of wall is made only with lime. In addition, the houses of Safranbolu have been plastered also with a special plaster, a mixture of egg white, goat hair, clay, lime and olive oil. This special plaster ensures the moisture balance of the environment and permits air permeability of the wall and creates a wall surface similar to today's satin dye [4].

6.6. Smoke, Heating Tools and Air Conditioning

The cooker (oven) being the source of smoke at the traditional Turkish house is found both in the kitchen and in every room. The kitchens have been built separately at the ground floor of the houses or in the garden with concern for smell and fire. Therefore, the house is prevented from being influenced by the smoke coming out during cooking process. As for the smoke discharged from the ovens situated at the rooms used to be generally well discharged to the atmosphere due to its cone – shaped chimney. Because of the wall material, the wall construction technique and the plaster feature, used to be naturally ensured the constant fresh air circulation at the indoor space. Starting from 19th century, the gases coming out of the stoves used to heat the rooms were being discharged to the atmosphere with the aid of pipes and chimneys. The stoves and cookers were not being used generally at night and when the southwestern wind blows.

Starting from 18th century, the wooden shutters found in front of the windows have been made to prevent the heat loss at the houses and ensure the indoor air ventilation. Usually a two – row window system have been introduced; the shutters used to be closed in the lower windows, the window used to be opened and the room used to be naturally ventilated. In some houses, for example in Urfa house, the natural air conditioning of indoor space have been arranged to be aerated by a series of windows contained above the regular windows called "takas". In addition, the underneath of the bay window encircled with windows contained and used at one end of the sofa from the traditional Turkish house is empty; owing to its wooden spaced – girder flooring made towards the direction where the wind is generally suitable according to region, the natural air circulation has been provided inside the indoor space [41]. As the bottom side of the bay windows is not insulated in the hot climatic regions, they are more open to the airflow. As for the underneath of the bay windows made in the cold regions, heating the space has been ensured as it has been insulated by being plastered with adobe mud.

6.7. Pipes and Installation

The spaces like kitchen, bathroom, toilet and bathroom available at the traditional Turkish house used to be generally contained at the ground floor of the house. In the periods when the modern installation materials and city drinking water network were not available, it has not been possible to bring water to these spaces or to bring them to upstairs. In the case of sewage installations, generally made of terracotta, the earthen pipes are insulated with a special mortar called "lögün", ensuring the drainage of water from the ground and upper floors [42]. Therefore, it can be said that there is not any situation which affects indoor ambient air quality from the perspective of installation from these houses.

6.8. Radon Gas

The installation pipes and soil come first at the beginning of the sources of radon gas emerged at the indoor space. As mentioned above, the installation at the traditional Turkish house is less and since the installation has not encompassed the entire house, it is a weak possibility to establish a radon gas and indoor air quality relationship in terms of installation.

The radon gas and indoor space air quality relationship at the spaces of Traditional Turkish houses with compacted floor (like room, cellar and barn) can be searched at Marmara Island, Uludag, Western Anatolia and Istanbul houses where the rocks being the source of radon gas are abundantly found. However, these houses are healthier in terms of radon gas if it is thought that today's reinforced concrete buildings are constantly emitting radon gas and causing toxic effect on the human body, because the houses are mainly made of wood-based materials. On the other hand, the natural materials such as granite and wild pear stone are determined to cause also liver cancer with the studies conducted due to containing radon gas and various harmful minerals [43](URL-6).

In addition, there are above – foundation ventilation gaps and ventilated foundation systems at the traditional Turkish construction technology. This basic system has been used in Anatolia since the Cayonu Houses in the Neolithic Age [44]. For example, in the construction of Dolmabahce Palace, ventilation gaps have been built on the basement floors. These air gaps have been built to provide continuous air circulation in the building and to prevent the damage of long – term accumulated moisture to the structure. Also at the spaces made by carving inside the volcanic stones within Cappadocia region, the chimneys by which the natural air circulation have been made. Even though the tectonic ground structure of region where these spaces are located

is very susceptible to the accumulation and release of underground gases, this problem has been remedied with the aeration systems [45].

As a precaution against harmful Radon gas accumulations, the areas on above the foundation and below the living areas should be thoroughly ventilated. To do so, it is suggested that air gaps and ducts are made beneath the ground floors and the basement concrete at the contemporary buildings. Ventilated basic and wooden spaced – girder flooring systems at the traditional Turkish house undertake this task.

VII. Discussion And Conclusion

Thanks to the wisdom and the experiences acquired, the human being has struggled to maintain the harmony of surroundings she / he has built with the nature throughout history. Today, this harmony is being consciously tried to be achieved with the concepts such as ecology and sustainable design.

Due to form of the construction technique, material and practice, the traditional settlements, especially the traditional Turkish house are the significant examples from the perspective of a sustainable architecture as the spaces were built from the ecologic materials which is easily worked and do not pollute the environment and can be easily recycled and ensure perfect harmony with the topography, climate and green texture and can be heated and cooled without requiring additional measures due to their natural insulation and can provide self-ventilation. These houses show ecological conformity in terms of variables such as building form, plan type, width / length ratio, building height, roof type and inclination. In this context, the relationship of air and light of outer world has not been interrupted with use of wood, stone, adobe materials, cages and shutters, bay windows, divans, floors and ceilings at the indoor spaces from the traditional Turkish house.

As a result, in terms of overall planning and construction characteristics, it is possible to say that the traditional Turkish houses generally have the features that eliminate the factors affecting the indoor ambient air quality. Experimental researches should be conducted on the samples selected according to the regions. Today, however, the examples of traditional Turkish house are exposed to vanish due to lack of maintenance and being inhabited herein. As for the buildings restored, the traditional residence demolished is firstly built as reinforced concrete form and then it is dressed in form of an authentic residence appearance or various applications which would ruin the originality of the houses have been made. For example, like use of varnish, polish on wooden surfaces or impregnation of timber with chemical substances. Moreover, the restored houses now serve different functions, just like a museum that has lost its function. Therefore, determination of traditional Turkish houses which are inhabited and maintain its originality in all aspects, if any, and examination hereof from the perspective of indoor ambient air quality would make up a significant study ground.

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