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# Traditional Methods of Air Cooling in Buildings of Middle Eastern Countries with Hot Dry Climates

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**Abstract:** This article presents and analyzes historical data on traditional methods and folk inventions used for air cooling in the buildings of Middle Eastern countries (Iran, Afghanistan, Pakistan, Tajikistan, Uzbekistan) with hot and dry climates during the summer season, and relevant conclusions are drawn.

**Keywords:** Middle Eastern countries, hot-dry climate, traditional air cooling methods in rooms.

**Introduction.** When discussing various architectural structures and inventions created by skilled master architects and engineers of the past, it is also necessary to mention the measures and methods aimed at reducing high temperatures in rooms of historical palaces, residential buildings, and public spaces during the summer season. Since ancient times, the climate of Central Asia, including Uzbekistan, which is distinguished by high summer temperatures, scorching heat, and low precipitation, has compelled the population to invent various engineering structures and devices. People tried to adapt their living environments to the harsh ecological conditions of hot dry climates. As a result, due to the ingenuity of the local population, ancient sophisticated devices were developed to reduce indoor temperatures in homes and other buildings. Studying these methods and devices is also beneficial for modern architecture and construction practices. This topic is well covered in the book by Tajik architectural doctor S. Mukimova “Restoration and Reconstruction of Cultural Heritage Monuments of Central Asia: Theory and Practice” (Dushanbe, 2022). However, this issue has not yet been sufficiently studied in Uzbekistan.

Main part. Based on historian Bayhaqi’s era, archaeologist A.K. Mirboboev provides information about one such invention. During the time when the successor of the Ghaznavid palace, Mas'ud, was the governor of Herat, he built a special house for rest in the Adnan garden. The house rooms were equipped with a cooling system using water, which was unusual for that time. Ceramic pipes with small holes were installed along the roof's perimeter. "Moto" woven from reeds were hung on these pipes. With the help of a special device called “Talisma,” water was lifted to the roof of the house, then distributed through the pipes and moistened the fabric. This method helped maintain a cool temperature inside the house.

According to historian Adam Metz, a similar method of reducing indoor temperatures was known in Baghdad in the 9th century. However, there, ice was placed between the outer walls of the house to cool the room during the day’s scorching heat. The Arab geographer Abu Dalaf, who visited the capital of China in the 10th century, noted that the Chinese lifted water to the roof of houses, which then dripped down from the motes hanging from the roof. It is said that the

inventors of the water-lifting device “talisma” were from Central Asia. For example, the devices used in Herat are believed to have been developed by Beruni. It is likely that Beruni based this device on the water wheel – the paddle wheel – familiar to him from his life in Khorezm.

The inventions and devices mentioned above are not the only ones developed in the past to protect from scorching heat. Many houses in ancient Central Asian fortresses had underground rooms called “sardobkhona.” For instance, it is known that the Uighurs lived in underground rooms during the summer. In Tunisia, cave-like underground rooms were built, opening to a common courtyard and forming unusual open-roofed residential spaces. In the center of the courtyard was a hole under which a subterranean water reservoir was located. This reservoir not only supplied water to the underground dwellers but also significantly cooled and humidified the air in the rooms.

Nasir Khusraw, returning from a pilgrimage to Mecca, noted that in the city of Argun (Basra region), for every aboveground house, there was a corresponding underground room. These included running-water sardobas where people spent the scorching summer season. The term "Sardoba" here literally means "underground room." Research by A.K. Mirboboev indicates that in cities, public sardobas always provided the population with a place to rest on hot days.

Historian Bayhaqi tells the story of Mahmud of Ghazni’s campaign to Ray and the participation of his son Mas'ud: “It was hot, and the elders and nobles ordered the construction of a sardoba for daily rest. A very attractive and spacious sardoba was built for Amir Mas'ud, where he rested from dawn till sunset, enjoying leisure and secretly drinking wine.” According to the testimony of theologian Abu Harun Katib, who lived in the 9th century, there were 1,200 sardobas in Balkh at that time. Some sardobas were used for storing drinking water, others served as shelters from the heat. In hot and dry climatic regions of Central Asia, there are many other methods of cooling rooms and entire courtyards: sheds, verandas, porticos, pools, fountains.

In houses and dwellings from the 9th-10th centuries, along with windows and light chimneys, there were also special devices that captured wind and directed it into lower rooms. Such devices resemble the large ayvons built in Khorezm folk houses to catch wind and direct it into the courtyard. Returning to the 9th-10th century wind-catching dwellings, it should be noted that many houses had lattice towers above their domes. Their openings faced northwest, where the prevailing winds blew. These towers were called "badgir" or wind catchers. Archaeologists have found similar structures known as “air channels” in many Middle Eastern medieval buildings. Such wind catchers in the form of towers were also part of residential buildings in Herat, Afghanistan. A book titled “Architecture of the Islamic World” was written based on such badgirs. The same book contains a colored illustration of a domed building surrounded by five badgir towers with lattice wind catchers at the top. Ice storage facilities were also built in Iran; a photo of one is included in that book.

As a continuation of traditions, a type of ventilation device called “badbarak,” installed near dwellings along mountain rivers in mountainous regions, can also be mentioned. Its structure is very simple. It is a device that rotates under the pressure of water directed onto blades like in mills. On this wheel, a vertical wooden rod is installed, to which a “moto” is attached. Built next to rest areas, this badbarak rotated during hot periods, drove away flies, and brought cool air.

It should be noted that the above-mentioned examples of engineering art from Eastern peoples have not gone unnoticed by modern builders. For instance, in Bareilly (India), a residential building with an underground tunnel was built, where moist walls created an effective cooling system. This experimental tunnel reduced indoor temperatures from 40°C to 26°C. The tunnel has a total area of 93 m² and provides enough cool, moist air to cool an area of 130 m².

Another example: in many regions of North Africa, the Middle East, and the Indian subcontinent, there is a widely practiced method where all room openings are covered with thick mats constantly moistened with water coming from perforated hoses. Thus, the hot dry air is moistened and cooled before entering the room. Air circulation is often difficult among compact,

dense buildings; in such cases, wind-catching holes are installed at the upper parts of roofs to allow air to enter the rooms. As a result, distinctive roof shapes can be seen in the cities of Hyderabad and Sindh in Pakistan. Wind catchers in Hyderabad were taken as examples in the U.S. and were reflected in the architecture of the energy-saving pavilion at the 1982 Knoxville exhibition.

Scientist D. Oakley, in his book "The Dwelling of the Tropics," described the ancient evaporative cooling method used in Egyptian villages. This usually involved a chimney-like structure that performed the opposite function. Before entering the room through the roof ceiling, the breeze passed over earthenware pots filled with water placed on charcoal platforms.

M. Aitchison observed an even simpler method of evaporative cooling used by farmers in dry and hot regions of South Africa. The device, typically placed above an elevated water tank next to the house, consisted of wooden frames (10.2 x 1.0 m) made of beams, with galvanized wire mesh of 0.64 mm thickness stretched on both sides. A 10.2 cm thick cavity was formed between the two meshes and filled with 3.81 cm diameter pieces of coke. Water pipes of 2.54 cm diameter were installed along the frame's perimeter and connected to a drainage tank. The water supply device regulated the system, keeping the structure's walls constantly moist, thus cooling the room.

Aitchison proposed borrowing this South African idea for cooling an entire building by installing moist screens filled with coke around the entire basement. A conveniently placed exhaust device could stimulate convection currents and provide cool air to the rooms day and night. Since this installation is placed around the entire house, its effect does not depend on wind direction.

Returning to traditional air cooling methods in rooms in Middle Eastern countries, we see that the use of ice in the past was given special attention. Ice played a significant role in urban life. In addition to cooling rooms, it was used to cool drinking water, preserve and transport perishable food products, and in medicine. Ice and snow were stored in winter for summer use. Facilities for ice storage were sometimes called "yakhchol," in other cases "sardobkhona," "gunbadi yakh," or simply "refrigerator." In some cities, the number of ice storage places was considerable. For example, in Khujand (Tajikistan), as A.Q. Mirboboev discovered, in the 18th-19th centuries, there were five state-owned and more than fifteen private underground ice storage cellars: Tajikkal icehouse, Mirrahim the iceman's icehouse, Eshon the iceman's icehouse, Qurbon the iceman's icehouse, Ikromi Maruznachi's icehouse, Qal'a icehouse, and others.

The design of Khujand's cellars was very simple: rectangular pits 2–2.2 m deep and measuring 5x12 m, with 2–3 pits dug along the longitudinal axis. They were filled with melted snow water in winter. The walls were reinforced with mesh woven from branches of mulberry or willow and covered with straw. The mesh, about 1.5x1.5 m in size, was attached to the cellar walls using wooden stakes, serving as thermal insulation. Beams were laid across the width of the cellar, with several transverse beams placed on top. Thin boards made from cotton stalks or reeds were placed on the transverse beams. Ice mixed with snow was then placed on this floor. If there was no snow, it was replaced with straw. The ice on top was also covered with a layer of straw. The roof was usually flat. Above the cellar, there was always a room or shed used for summer rest. Ice was preserved in such cellars for quite a long time.

According to Abu Harun Katib, during his lifetime, there were about 400 ice storages in the city of Balkh. According to some information, in mountainous areas, large warehouses were also available for storing snow and ice.

The village of Shodyan, located on the outskirts of Balkh, supplied the city with the required amount of snow for the needs of the Balkh palace during the summer. Istakhri and Ibn Hawqal also report that in Samarkand province, there were more than 2,000 icy sardobas that provided visiting guests with cool water and ice. Geographer al-Yaqubi wrote that Abdullah ibn-Tahir built an ice storage called "shadyah" in Nishapur. In the Nishapur Jami mosque, which could accommodate more than 60,000 worshippers, there was a large cellar for storing ice, which was

used to meet the needs of the city's population in summer. The construction of the cellar was attributed to Abumuslim Marvazi.

As mentioned above, the use of ice in the past was very widespread. First of all, ice was used to cool buildings, drinking water, to prepare the local delicacy "Rohati-Jon" ice cream and "dughob" – yogurt. In summer, people drank wine only with ice. Historian Bayhaqi mentions that Sultan Mas'ud of Ghazni, during his stay in the city of Bust, was in a dark room cooled with "hanging canvas fabrics" moistened with water, and large pools were filled with water and topped with ice. Ice was also used to preserve vegetables, fruits, and melons and transported over long distances in special tin boxes filled with ice.

Ice was also used for medicinal purposes. In particular, Avicenna recommended in many of his treatises to observe moderation when cooling water with ice, not to add too much ice to the water, as it could harm the nervous system. He advised giving icy water only to people who were overweight or had high energy. His advice remains relevant today.

In the past, chefs used ice to prepare a dessert called "poluda," which later became a prototype of ice cream known as "Rohati-Jon." After Marco Polo's travels to Central Asia, the secret of making ice cream spread to Europe. "Rohati-Jon" is still sold in the markets of Samarkand and Bukhara: a master chef scrapes a piece of ice in front of you to prepare ice cream and pours several spoons of grape syrup over it. All this is mixed well and ready to eat. Even in the 10th century, local masters prepared high-quality and diverse ice creams.

In many parts of Uzbekistan and Tajikistan, the tradition of using ice is still preserved. For example, in the 1950s in Darvaz, a summer sleeping place called "yakhdon" was built. Even today, in many mountain villages of Tajikistan, dairy products are stored in such yakhdon refrigerators.

**Conclusion.** The above information shows us the traditional, widely practiced, and proven methods of air cooling used during the summer season in hot and dry climates of Middle Eastern countries (Pakistan, Afghanistan, Tajikistan, Uzbekistan). These methods are still practically relevant today. Therefore, their use in remote villages and settlements of Uzbekistan with hot and dry summers would be beneficial. These devices are very inexpensive and have been tested among the people.

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