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ANCIENT HYDRAULIC STRUCTURES DESIGNED FOR WATER FLOW REGULATION, COLLECTION AND STORAGE

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Abstract
This article examines ancient hydraulic structures that played an important role in regulating, blocking, collecting and preserving water resources. The study highlights the functional diversity and engineering significance of traditional water-management facilities used in historical irrigation systems. Particular attention is given to structures such as dams, temporary barriers, diversion embankments, sluice-equipped dams, brick dams, pools, gated pools, stone-lined water pits, sardobas and underground reservoirs. These structures demonstrate the high level of practical knowledge, engineering experience and water-use culture developed by local communities in response to natural-geographical conditions, seasonal water scarcity and the need for sustainable irrigation and drinking-water supply.

Keywords: Ancient hydraulic structures, water flow regulation, dam, water barrier, temporary barrier, diversion embankment, sluice, brick dam, reservoir, pool, gated pool, sardoba, underground reservoir, water storage, irrigation, traditional water management, hydrotechnics.

Introduction

This group of structures was studied by such authors as Ya. Ghulomov (1957), B.A. Latinin (1959), A. Muhammadjonov (1968, 1972), V.A. Shishkin (1969), and B.V. Andrianov (1969).

Dam

Within the group of ancient hydraulic structures intended for blocking water flow, dams constitute a separate type. The term tog‘on is of purely Turkic origin and conveys the meanings of placing an obstacle in a watercourse and blocking it. According to their construction and the scale of water accumulation, these structures are divided into two types: bog‘it and band.

Bog‘it

This is the most primitive and simplest form of dam. Therefore, local raw materials, such as rock fragments, soil, branches and brushwood, were used to block the watercourse. Naturally, in such cases the flow moving along the channel was partly obstructed but not completely stopped; it continued to move along the channel to some extent. Nevertheless, such a structure created an opportunity to accumulate a certain amount of water behind it. Bog‘its are characterized by simplicity, seasonality and temporary functioning. The concept of bog‘it is also purely Turkic and means “to choke” or “to block” a waterway. It also has another Turkic equivalent, qir. Qir means a dam or a place where water accumulates (Mahmud al-Kashgari, 1960, p. 314). These structures may perform different functions. Accordingly, there are subtypes such as to‘sin and qochi.

To‘sin

Its function is to block the movement of a river or stream along its channel. For example, it is known that the bog‘it built on To‘sinsoy (Southern Nuratau Range) was constructed from simple local materials [information obtained from informants during field surveys]. It was built in the middle reaches of To‘sinsoy; the hydronym itself indicates that a to‘sin once existed at this point. The structure was located at the narrowest part of the stream, south of the present-day village of Ko‘lto‘sin. A reservoir-lake formed behind it, and later the village of Ko‘l To‘sin, which still exists, emerged to the north of the structure. However, no additional information is available about when and how this to‘sin was built.

Qochi

Its difference from a to‘sin lies in the fact that it is built along the bank, parallel to the direction of the flow. Thus, qochi is connected with the verb qochmoq, “to run away” or “to escape”, and denotes a structure that prevents water from escaping laterally through low sections of a riverbank. For example, during flood periods of the Amudarya, qochis built along the banks protected the surrounding areas from inundation (Ya. Ghulomov, 1958, p. 272).

Band

In Persian, this term means “to bind” or “to fasten”. Compared with a bog‘it, it is a technically more complex type of ancient hydraulic structure. Rock fragments, fired bricks, timber and special binding mortars were used in its construction. In addition, such structures had special kulfak-sluices for passing a certain amount of water. As a subtype, band is divided into three forms: ko‘rband, halqaband and g‘ishtband.

Ko‘rband

In order to block the flow, various locally available inert materials such as sand, gravel, turf, soil, branches and brushwood were used, and the channel was completely closed. As a result, the excess flow passed over the ko‘rband, or, in some cases, could not pass at all.
Field observations conducted in Southern Nuratau, using the Kattariq canal fed by Oqtepasoy as an example, showed that special wooden devices such as sinch, zabarrov and qoziq were also used together with inert materials in the construction of ko‘rbands.

Nishband

Its difference from a ko‘rband is that an opening called nishtag is left along the right or left, relatively more stable shoulder of a canal or river to allow a certain amount of water to pass. If it is necessary to reduce the water flow, the size of the nishtag is narrowed with the help of stakes and zabarrovs; otherwise, it is widened. In this way, the level of the accumulated backwater could be “raised” or “lowered” and regulated.

Halqaband

Branching poles and brushwood were widely used in its construction. After parts of the poles and branches were placed in a ring-like form over special stakes for damming, a layer of brushwood was laid over them, followed by a second layer of turf and heavy rock fragments. Thus, a multi-layered barrier that resisted the flow was formed.
On the channels of large rivers such as the Amudarya, Syrdarya and Zarafshan, fascines were used to build dams. In the Zarafshan valley fascines were called navala, in Khorezm navard or vard, in the Fergana Valley o‘luk, and in the Syrdarya oasis qorabura. Fascines were made in cylindrical form from branches and reeds; their interior was filled with stones, turf and gravel, and they were tightly tied crosswise in three or four places with tamarisk or reed bundles, then rolled into the river. Three-legged and four-legged supports were also used in dam construction on such rivers (A. Muhammadjonov, 1972, p. 287).

G‘ishtband

Unlike ordinary ancient hydraulic structures such as dams, bog‘its, to‘sins, qochis, bands, ko‘rbands, nishbands and halqabands built from inert materials across our region during the Middle Ages, a g‘ishtband was constructed from fired brick, local rocks such as limestone and granite, and a special mortar called qir. The g'ishtband was a complex structure and, at the same time, one of the most ancient waterworks.

Three such structures in the territory of the republic have been studied by archaeologists: Khanbandi (10th century), located below the confluence of Osmonsoy and Ilonchisoy, which originate on the northern slopes of the Nuratau Mountains; Abdullakhanbandi (16th century), built east of the present-day village of Oqmachit along Oxchobsoy, which originates on the southern slope of the Nuratau Mountains; and G'ishtband (12th century), located on Omondarasoy, which begins on the western slope of the Zarafshan Range (Ya. Ghulomov, 1957, p. 61; N.M. Muhammadjonov, 1972, p. 305).

Although these structures were built a thousand or five hundred years ago, they did not resemble one another in terms of operating technique or dam design. Nevertheless, they were equipped with strong special devices, namely sluices. If we compare these remarkable examples of medieval irrigation technology with modern waterworks, then, although they belong to the category of medium-head hydraulic structures, in terms of their engineering complex they were constructed almost at the level of modern reservoirs (Muhammadjonov, 1968, p. 27). This means that ancient irrigators knew very well, from an engineering point of view, the geological-tectonic structure, hydrology and hydrogeology of the area where a reservoir dam was to be built.

In fact, the bands that formed ancient reservoirs were probably more numerous than the three examples listed above. In some areas, alongside scholarly indications that such structures were built, there are also oral reports and certain toponyms that confirm their existence. For example, since the Dargom Canal flowed very deeply, at a depth of 15-20 m, across the Dargom steppe, a reservoir was built in ancient times along Yomonjarsoy, which developed parallel to it. This reservoir irrigated the plains behind the Dargom Canal. Therefore, even at the beginning of the twentieth century, irrigation traces and fortress mounds existed in these areas, testifying to a long history of intensive irrigation (V.A. Shishkin, 1969, p. 116). In Surkhandarya Region alone, the etymology of the toponyms Vandob, actually Bandob, and Bandikhon suggests that there was once a band blocking the waterway at these points. Although the materials from which they were built remain a matter of debate, it is known that they were mostly constructed to collect floodwater. For this reason, ancient selkhonas as hydraulic structures have completely disappeared in our time, while their names have been preserved in some places as toponyms. One example is a stream and village located on the western slope of Bobotog' in Namangan Region; Selga was originally called Selgoh (S. Qoraev, 1978, p. 110). From a physical-geographical point of view, the body of water accumulated behind a band was called ko'l, "lake", in antiquity. Some written sources also testify to this. Herodotus, speaking of reservoirs built in the third century BCE, or perhaps even earlier, and denoted by the term ko'l, reports the following: "Among the Arangians there is a valley surrounded by mountains." These lands belonged to the Khorezmians. The ruler blocked the place where water flowed out of the mountains and built gates-bands at each outlet; the water exit was closed, and the valley among the mountains turned into a lake because water entered but could not leave (Herodotus, 1964, p. 117). This account also shows that the dam had gates, that is, water-passing sluices, while the reservoir filled with water was called a koʻl. However, the location of this structure either did not become a toponym, or, if it did, the name has not survived to our time. According to Ya. Ghulomov, this area corresponds to the Herirud Valley adjacent to the border of Turkmenistan. The Greek author confused it with Ak-Araks, calling it Ak-Akes, and identified it with the Oxus-Amudarya (Ya. Ghulomov, 1957, p. 37).

Indeed, the concept of a "reservoir" formed behind a dam emerged as a folk geographical term somewhat later. Therefore, the village of Koʻlitoʻsin, located along Toʻsinsoy in the foothills of Nuratau, also appears as an ancient toponym. In antiquity, this concept was represented by the term suvxona. It is clear that by the tenth century this folk geographical term was already in use (Mahmud al-Kashgari, 1963, p. 186).

It should also be acknowledged that ancient hydraulic structures used for blocking water flow in the territory of the republic and adjacent regions were expressed not only through Turkic terms, but also through terms related to Sogdian, Persian and even Arabic. As a result, alongside terms for blocking hydraulic structures such as togʻon, band, bogʻit, toʻsin, qochi, koʻrband, nishband, halqaband and gʻishtband, dozens of folk geographical terms entered the scholarly literature as their equivalents or associated designations: sarband, dargʻot, doldargʻa, bast, vargʻ, ras al-vargʻ, dargʻ, dargʻot, xonband, taxta, kunda, sepoya, chorpoya, ustun, goʻsha, sinch, zabarrov, kulfak, dahana and quloq. This indicates how ancient and highly developed the culture of water use was in our country. Wherever water-use culture is highly developed, the range of values and terms formed in connection with it, as its reflection, also becomes highly diverse.

Ancient hydraulic structures in this group consisted of facilities capable of collecting water reserves in quantities sufficient for all seasons, reducing infiltration and evaporation, and preserving water quality. As a type, they were called moʻyanlik. Indeed, structures called suvxonas, built for benevolent purposes and, in general, to quench people's thirst, were known as moʻyanliks (Mahmud al-Kashgari, 1963, p. 188). Within this type, subtypes include hovuz, kulfakli hovuz, toshqoq, sardoba and underground reservoir; as lower-order forms, toshhovuz, yogʻochhovuz, gʻishthovuz, sozhovuz, qimir and hovuzband are also represented.

Hovuzes

V.L. Vyatkin (1927), V.I. Kochedamov (1957) and L.I. Rempel (1981) studied these hydraulic structures from archaeological and art-historical perspectives. According to their functions and construction, hovuzes are classified as toshhovuz, yogʻochhovuz, gʻishthovuz and sozhovuz. Their main purpose was to preserve water reserves for consumption over a long period without degrading their quality. These hydraulic structures may be conditionally studied by dividing them into main and auxiliary parts. The main part is the water-storage bowl, the quality of which depends on its geographical location, whether in foothill or plain areas, and on the composition of the ground, such as sandy loam, clay soil and other materials. Depending on these conditions, it could be additionally reinforced with construction materials. This occurred when one of three needs arose: when infiltration through the base of the pool was high; when there was a risk of water quality deterioration; or when decorative work was desired.

For example, in mountainous, foothill and partly plain areas around Samarkand, Nurata, Shahrisabz and Bukhara, marble, marble-like limestone and granite were available, while juniper wood was found near Urgut; therefore, these materials were skillfully used as inexpensive raw materials. In all cases, because the raw materials were natural, the storage duration and quality of water remained excellent. Wooden bases may have served for a shorter period than stone bases, but because juniper wood contains resin, it is known to be several dozen times more resistant to water than even the hardest mulberry or elm bases. For instance, juniper timbers used 2,000 years ago in the galleries of the Qizil Olma gold mine in Tashkent Region have been well preserved for 1,000-1,300 years under constantly damp conditions at a depth of 120-150 m (Mineral Resources of Uzbekistan, 1978, p. 93).

Because decorative requirements were more common in urban pools, marble was used for this purpose in cities such as Samarkand, Nurata and Bukhara.

Rural pools were usually excavated in ordinary soil without additional materials. If a pool had to be dug in sandy-loam ground, infiltration was reduced by repeatedly filling it with turbid water, preferably floodwater where possible. In areas with clay soils, the base of a newly dug pool was thoroughly trampled by horses or by animals such as donkeys and oxen; in some cases, even without this procedure, the structure was filled directly with water.

The auxiliary parts of a pool include the marza-sufa surrounding the base on all four sides, raised 0.5-1 m above the water level and 3-4 m wide, as well as the nov and protective trees planted along the bank. One practical function of the sufa is to prevent water from spreading into the surroundings when the level rises. A second function is protective: it prevents snowmelt, rainwater and wastewater accumulating around the structure from entering the pool. To allow snow and rain falling on the sufa to drain outward, its surface is made slightly inclined away from the pool. Third, it serves as a recreation area. As noted above, the sufa and protective planting are integral parts of a pool; without them, the structure cannot be considered complete and becomes merely an ordinary pit.

Protective plantings consist of densely planted willow, poplar, sada elm, mulberry and similar trees. Their function is to reduce evaporation from the pool surface, create a pleasant cool microclimate around it, and partly protect the pool base from external contamination.

In urban areas, pools were built in four-, six- or even eight-sided, arched or elliptical forms for decorative and aesthetic reasons. Rural pools, by contrast, were usually simple rectangular or sometimes round structures.

According to the water-exchange regime, pools are divided into two categories: those with outflowing water and those without outflow.

In pools where water was frequently renewed, both the inlet and outlet openings were left open during the renewal process. Only after the incoming clean water completely flushed out the old stagnant water was the inlet closed, while the outlet remained open. When the water level reached the outlet, the flow stopped automatically. The water in such pools was usually clean and pleasant-tasting enough to meet sanitary requirements.

The water capacity of pools could vary depending on the consumption needs of a mahalla or village. For example, among the three ancient pools of the same age as the ruins of old Afrosiab, the largest had a capacity of one million buckets of water (V.L. Vyatkin, 1927, p. 7), whereas small pools intended for one or several households held only a few thousand buckets. In the Muslim world, when pool size was considered from the standpoint of sharia, according to the fatwas of Imam Qozikhon and Imam Zahiriddin Bukhari, may Allah have mercy on them, a pool was required to measure thirty-six gaz; according to other sources, its perimeter had to be forty-eight gaz (Chor Kitob, 1994, p. 39). Such varying instructions regarding pool dimensions were expressed on the basis of different geographical locations and physical-geographical conditions.

Because building a pool and selecting its location required special expertise, there were master craftsmen known as hovuzgar. Usto Majid, who lived in Bukhara at the beginning of the twentieth century, was one such specialist. He built eighteen pools and restored such ancient monuments as Hovuzi Nav, Bobo Niyoz, Khoja Zayniddin, Msak and Bolahovuz.

The master was especially skilled in decorating the bottoms and walls of pools with stone. Before laying stone on the pool bottom, he placed mulberry timber horizontally and evenly on the ground; after installing black-marble plates on the bottom of the structure, he lined the banks with black-marble blocks cut in a stepped form (I. Rempel, 1981, p. 150). Pools with such stepped inner sidewalls still adorn historical monuments and courtyards in the city of Bukhara today.

As noted above, pools were located densely or sparsely depending on how close a settlement was to its main water sources, such as a river, stream, canal or ditch. According to the Russian Institute of Tropical Medicine, in the 1920s there were 103 pools in the city of Bukhara alone (I. Rempel, 1981, p. 146). In our time, however, not only in cities and other densely populated settlements, but even in the most water-demanding rural areas, pools have virtually become rare monuments. This situation developed due to the following factors: severe pollution of running-water sources; disorderly use of groundwater resources; heavy contamination not only of water but also of the surface soil layer with various chemicals, petroleum products and toxic compounds; and the decline of reverence for water among local communities, among others.

One of the oldest surviving examples of simple pools in the Qashqadarya oasis is located in the village of Pudina in Koson District (Figure 3). This simple earthen-bowl structure is situated in the courtyard of the mausoleum of Qusam Shaykh Muhammad.

Gated pool (kulfakli hovuz)

Although this hydraulic structure has existed in the foothills of Nuratau since ancient times, the concept of kulfakli hovuz was introduced into scholarship by A.M. Muhammadjonov (1968). We propose to use the geography of gated pools as an official concept for the area that borders the Nuratau Mountains and the Ziyovuddin-Zirabulak Mountains, because our research shows that this type of hydraulic structure is distributed precisely across this territory. In fact, it is possible that they also occur in other areas. Their antiquity is indicated by their direct association with the water supply of ancient fortresses such as Xushang and Pashshot. In this area, more than twenty gated pools function along Ustuk, Oxchob, Qoʻshtamgʻali and other streams; five gated pools operate on Ustuksoy alone. In total, 42 gated pools, qimir structures and hovuzbands were investigated in the Nuratau, Zirabulak-Ziyovuddin, Tim and Piyozli Mountains.

Because of their morphological dimensions and external appearance, gated pools resemble ordinary pools or small reservoir-bands. In reality, they are neither pools nor bands. Their engineering features, the geomorphological position of the selected site, and their function sharply distinguish them from both types of hydraulic structures. If an ordinary pool is created by digging a deep pit in flat ground, a gated pool, by contrast, is built above the ground surface along the side of a stream or on a terrace-like flat area near a slope, with three sides raised by walls made of stone and turf, and sometimes mud-brick; in many gated pools along Ustuksoy, the wall base is 2.2 m and the upper part 1.1 m. Clay soil was used for mud-brick in places such as Chinor, Uchqoʻl and Oʻrazmat, while in areas with less suitable soil, stone and turf were more widely used for the walls. In all gated pools, the wall height usually does not exceed 1.5-1.8 m. Gated pools, like ordinary pools, have inlet and outlet openings (Figure 4). However, while the outlet of an ordinary pool is placed at the surface level, equal to the upper water horizon, in a gated pool the outlet is located at the bottom on the side of the structure. A special marble slab measuring 1.5 x 1.2 m is pierced in the center with a 0.15 x 0.20 m opening, sometimes round, and a wooden plug made of mulberry or willow is inserted (as in the Pashshot gated pool). The specially processed marble lining prevents the erosive force of the water from washing away the wall or bottom of the structure when the plug is opened. When the plug is closed, not a single drop of water passes downward, and water coming from a scarce spring (Ustuk), a kariz (Pashshot), or a stream (Oʻrazmat) located above accumulates. On average, gated pools collected 1,800-2,000 m3 of water in one night if the plug was inserted in the evening. In the morning the gate of the pool was opened and the accumulated water flowed out for 7-8 hours (Muhammadjonov, 1968, p. 12). The importance of gated pools lies in the fact that even a small amount of spring or rivulet water could be collected, allowing the entire village, household by household and family by family, to irrigate their plots in turn every one or two days according to conditions.

The enormous role of gated pools in supplying the population with drinking water and supporting irrigated agriculture is evident from the geographical pattern of their distribution. Nevertheless, such rare structures are being neglected in the foothills of Nuratau. Like the gated pools that collected spring water in the upper part of Ustuksoy, many are being buried and are ceasing to function.

Qimir differs from a hovuzband by the relative simplicity of its gate-sluices. The geography of qimirs corresponds to the territory of the Zirabulak-Ziyovuddin, Tim and Piyozli Mountains, and their sluice-gates are installed in the lowest part of the front wall of the structure. Usually, the float-plug is replaced by a conically carved piece of wood. To release the mass of water accumulated in the qimir-pool, the wooden plug is moved or shaken and then pulled out. Otherwise, it is difficult to remove the plug from the qimir outlet. For this reason, the structure is called qimir.

Toshqoq

This type was studied by authors such as Ibn Battuta (1966), V.N. Kunin (1959) and E.M. Murzaev (1973). It is known that low-lying clayey areas on flat plains are called taqirs. Seasonal lakes form when snowmelt and rainwater moving toward their central parts accumulates there. These lakes are called qoq. Qoqs are seasonal ephemeral lakes formed at the central and deepest points of taqirs.

Taqirs are distributed in partly dried river deltas such as the Karakum, in clayey and saline depressions such as the Sarykamysh Depression and the Ustyurt Plateau, in all deserts, and sometimes even in foothill areas such as Northern Nuratau. Most of them, however, form in desert regions. Since water collected in taqirs was often fresh and clear, ancient caravan routes were directed along taqirs, and pastoralists gathered around them.

While crossing the Karakum in 1333, Ibn Battuta wrote that every two or three days he encountered water places where rainwater had accumulated on clayey ground (Ibn Battuta, 1966, p. 147). However, because of intense heat, evaporation and rapid infiltration into the ground, these ephemeral lakes quickly dried up; and because livestock and wild animal herds passed through them, most became unfit for consumption by the beginning of summer. Therefore, pits were dug in the centers of taqirs to reduce the surface area of evaporation and infiltration, and their tops were tightly covered with poles and felt to maintain good sanitary conditions.

This simple method of water storage was called chirli or toshqoq. Toshqoqs differ somewhat from qoqs in structure, as their walls were made of stone or brick. In antiquity, doshqoqlar were widespread in southern Uzbekistan and especially in Turkmenistan; dosh in Turkmen means “stone”, that is, toshqoq (A.N.). In terms of size, toshqoqs are quite large and sometimes reach 25 m in diameter (Murzaev, 1973, p. 44). Nevertheless, most toshqoqs are circular, with a radius of 3-4 m. In Unguz, in the Karakum Desert, doshqoqlar still existed in the 1950s (M. Qoraev, 1959, p. 117). After bore wells began to be drilled in large numbers, especially after the 1960s, the demand for toshqoqs declined considerably.

As a result, most of them were abandoned or became buried and ceased functioning due to neglect.

Another type of qoq is found in the foothill areas of Uzbekistan. In this case, spring snowmelt and rainwater is brought through small channels and collected in rocky depressions. Although the evaporation coefficient is high, the rocky layer beneath the water-collecting area sharply reduces infiltration. It would not be wrong to say that as the construction of qoqs became more advanced, sardobas emerged. The western parts of the Qashqadarya oasis do not consist only of deserts; they also include several low mountains about 500 m high, such as Qo‘ng‘irtog‘, Kosontog‘, Murodtosh and Maymonoq. Many qoqs could once be found along their slopes. According to local recollections, doshqoqlar also existed around the villages of Turkman and Pomuk in Muborak District.

Chirli

Like a doshqoq, this structure is built at the central points of depressions where rain and snow water accumulate. Its difference from a doshqoq is that the area consists of erodible sandy layers. To prevent the walls of the excavated water-collecting structure from collapsing, the perimeter of the pit is lined and protected with available local inert materials, including the stems and wood of shrubs and small trees such as saxaul, quyonsuyak and irg‘ay. Therefore, the name of this structure, chirli, corresponds to its construction.

Today chirli and doshqoq structures belong to the category of historical values that have almost been forgotten. Although the degradation of the ecological environment in deserts has caused sand movement and reduced the area of taqirs, they have not disappeared completely. Yet in recent times, because of indifference toward water, doshqoqlar and chirlis are no longer dug at all; existing examples are also buried under silt and sand due to neglect. Only certain toponyms, such as the village of Qoq in Kattakurgan District of Samarkand Region, preserve the memory of qoqs as monuments.

Sardoba

Sardobas are one of the types of ancient hydraulic structures widely distributed in Asian countries, including Uzbekistan, and sometimes in North Africa; they have distinctive geographical features. This subtype was studied by Nasir Khusraw (2003), P.I. Lerch (1870), N. Khanykov (1843), M.N. Galkin (1868), A.P. Khoroshkhin (1868), L.F. Kostenko (1870), P.A. Aminov (1873), F.A. Arandarenko (1889), V.V. Krestovsky (1887), V. Masalsky (1913), M.Ye. Masson (1935), A.M. Muhammadjonov (1972), L.I. Rempel (1981), A. Nizamov (2008) and other authors.

Based on the geographical distribution of sardobas across the republic, field surveys and published literature, it can be stated that a total of 57 sardobas existed in the territory of the republic and adjacent areas (table). Most of them are neglected and abandoned. The water of four could be used, but it is not being used. The reasons are as follows: 1) the area around the Porado‘z sardoba in Bukhara has in recent years been turned into a cemetery; 2) in the Khalifai Khudoydod sardoba in Bukhara, bitumen was used in the pool during restoration, so the water surface is constantly covered with petroleum products; 3) as in the sardobas of the Qashqadarya oasis, the quality of groundwater in many structures has deteriorated and become unsuitable for drinking; 4) no water accumulates at all in the Yog‘ochli sardoba in Mirzachul and the Eshoni Imlo sardoba in Bukhara; 5) because the Pomuq and Ochiq sardobas in the Qashqadarya oasis have no domes, water accumulates only in spring; 6) although the dome of the Qaynar sardoba in Tashkent Region has collapsed, the structure still protects its spring water from external contamination. At present it is the only sardoba in the republic whose water is suitable for drinking.

Underground Reservoir

This type of ancient hydraulic structure was studied by Nasir Khusraw (2003), Ibn Battuta (1992), M.Ye. Masson (1935), A.D. Davidov (1967), B.R. Duvbiy (1999) and Ye. Berezikov (1992). When the water of the Nile River rose, Masone pushed back the salty seawater around Tanis, an island city in the Mediterranean (A.N.), and the seawater became fresh at a distance of ten farsakhs from the city. To take advantage of these period, large and strong underground reservoirs were built on the island and in the city. All the water of the city came from reservoirs filled when the Nile rose. The local population, that is, the Arabs, called it Masone (Nasir Khusraw, 2003, p. 41). In Persian lands this structure was known by the term obombor, while Turkic peoples called it an underground reservoir.

Obombor

As the name indicates, underground reservoirs are built underground. They are special hydraulic cavities constructed below the surface, not very deep, about 5-6 m, but wide, about 15-20 m. Ibn Battuta also noted that in the fourteenth century there was an underground reservoir near the sacred Zamzam spring in Mecca. It dated to the sixth century, had a special entrance, and was built in a well-like form to keep the water of the Zamzam well cool (Ibn Battuta, 1966, p. 206). Other authors also confirm this view (B. Duvbiy, 1999, p. 29). A similar ancient facility has survived in the village of Omborkhona (!) in the Jalalabad oasis of Afghanistan. Water comes to it underground through galleries. Underground reservoirs have several water-discharge channels. When necessary, the released water is directed underground toward fields and comes to the surface only when it reaches the intended plot. One can descend into an underground reservoir by specially built stairs (A.D. Davidov, 1967, p. 47). The underground reservoirs of Mashhad were also hollowed out in the ground; their bowls were lined with fired brick like sardobas and covered above with fired-brick domes. Their difference from sardobas is that one does not enter the building to draw water; instead, water is taken from outside by means of specially installed copper ladles.

Ancient examples of underground reservoirs have also survived, though in ruined form, in Uzbekistan, specifically in the village of Xonimqoʻrgʻon, Yakkabogʻ District, Qashqadarya Region. The structure is located in the central part of the fortress, that is, beneath it, and its walls are lined with specially prepared thin, shaped fired bricks. Its water capacity exceeds 800 m3. This structure is an architectural monument dating to the fifth century. Its water came from a mountain spring located to the east, and the system was kept highly secret because the underground reservoir was the only source supplying the fortress with water. Therefore, the flow was brought underground in hidden form through special ceramic pipes. Excess accumulated water was discharged outside through separate spouts (Ye. Berezikov, 1992, p. 64). Whatever physical-geographical conditions underground reservoirs were built in, they were designed to keep water stored underground while protecting it from excessive evaporation and infiltration. Their engineering advantage over ordinary reservoirs lies in preserving the water mass from sunlight and preventing evaporation and infiltration. Because the water was protected from external influence, its drinking quality did not deteriorate. As a result, this type of structure acquired important economic and strategic significance.

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