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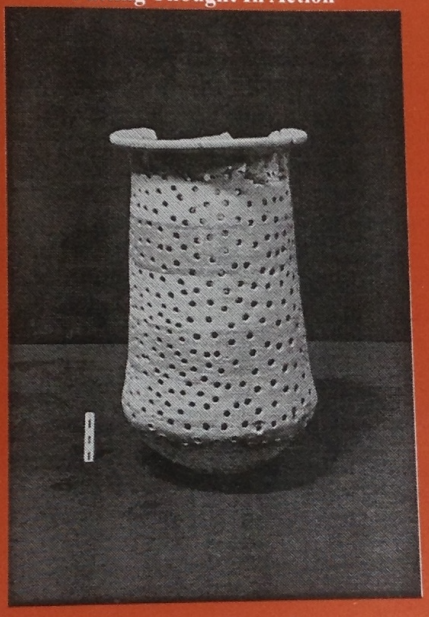
Atharva

Putting Thought In Action



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Indus Culture

Perforated Pots or Coolers for Perishable Food Items?

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Editor's Note

The Indus Civilisation continues to baffle the world for its antiquity and value. The archaelogical sites suffer from official and public apathy in India. The application of space, information and biotechnology has potential to reinvent the past. The river changes have led to disappearance of the Mohenjo-Daro and Harappa civilisation.

The myth of Aryan invasion continues to grip historians and academicians, despite fact that biological, literary and archaelogical evidence works against it. Both ethno-archaeology and experimental archaeology tries to understand the past by addressing questions with modern-day material culture. The archaelogical sites, remains, monuments give an idea of human behaviour, environment, organization and meaning based on the material culture of the past.

The perforated pots were used by Indus Civilization women probably as coolers for edible items. Perforated pots meant for 'soma' juice finds mention in the Rig Veda. The possibility of perforated pots being used as heaters or braziers, for burning aromatic substances, milk boiling to cover the boiling pot, making macaroni like food item from sorghum paste, catching fish, or, brewing say wine etc is discarded or needs more research. The study needs expertise, manpower, technical and instrumental resources.

The Government of India should provide more funds and infrastructure to the ASI, academic institutions to encourage research in archaeology. Moreover, the archaeology can serve as a potential tool to solve the environmental, developmental problems of today. The Indus Civilization gives us a picture of society that blended material progress with ecology.

INDUS CULTURE
Perforated Pots or Coolers for Perishable Food Items?

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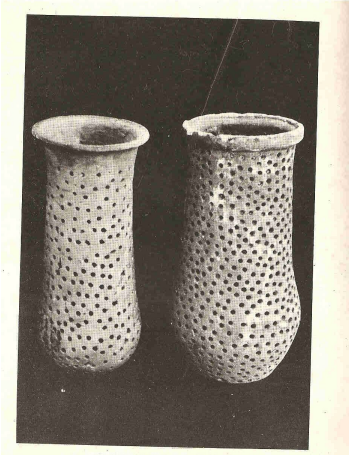
ABSTRACT
Several Indus culture sites show presence of perforated potsherds. In some instances full length of jar like perforated pots were unearthed. Excavating archaeologists and researchers on the Indus pottery and terracotta have given some clues about the use of these perforated pots that these were used as heaters, incense burners, strainers, etc. Iravatham Mahadevan has indicated that perforated pots could be the Soma juice strainer shown in front of sacred bull figures on the Indus Culture seals. But the pots on the Indus Sacred bull seals are invariably semispherical whereas the potsherds found in excavations point to jar like shapes. Author observed 5 – 8% perforated potsherds in some heaps in the pottery yard at Shikarpur in Kachchha. He conducted dimensional studies of these potsherds. Back home he got long and small sized perforated jars made by the local potter and conducted experiments on cooling effect on few vegetables and buttermilk. He observed that items kept inside the perforated jars remain at temperatures 5 – 10^{o}C lower than the ambient / room temperature. He proposes that the perforated jars were used as coolers for the household perishable food items in the ancient times.

INTRODUCTION
The Indus Culture (I C) potsherds invariably contain fairly high percentage of perforated potsherds. In some locations, like Lothal, Harappa, Rangpur, full pots have been excavated (Picture 1). I have visited some I C sites, namely Lothal, Surakotada, Khirasara, Dholavira Kotada in Gujrat before 1995. I visited Dholavira way back in 1989 before excavation was undertaken and then in 1992 when excavations were in progress under the directions of Dr. R. S. Bisht. Surface explorations during my both the visits yielded perforated potsherds. Recently in Februar, 2009 I had opportunity to visit the sites of Shikarpur and Kanmer in Kachchh, Gujarat. I was able to locate the perforated potsherds in large numbers at these locations.

The excavation reports of many Indus sites indicate occurrence of perforated pot of different sizes. A full pot was reported from Harappa (Vats 1940: Pl LXII.6), Mohenjo-daro (Mackay 1938: Pl LXII.29), Lothal (Rao 1985), a single piece from cemetery R37 at Harappa (Wheeler 1947: 115), Kot Diji (Khan 1965:Fig 12 items 17 and 21), Bara, Ropar and Raja Sirkap (Sharma 1993: Fig. 13.9, 13.13, etc.)

ON THE USE OF PERFORATED POTS
Extensive work on the Harappan pottery was conducted by Manchanda during her Ph. D. work: “A Study of Harappan Pottery”, (Manchanda 1969: 131 -136). There are a few books and articles which exclusively deal with I C pottery and terracotta. “Studies of Indus Valley Terracota” by Dr.

Govinda Chandra Rai (1974), “Prehistoric Pottery along the ‘Lost’ Saraswati River of the Great India Desert”, an article by Katy F. Dalal (2005), etc. Some excavation reports and books mention the possible use of these pots. (See Picture 1, Perforated pots from Lothal in Rao,1985 Plate 18).



18. Typical Harappan perforated cylindrical Jars.

Picture 1

There is only one instance, which possibly indicates the probable use of the perforated pot giving literary reference. Others have made guesses. Iravatham Mahadevan (1984: 219 - 266) has proposed that the perforated pot shown in front of the “sacred bull” seal was a Soma juice filter as described in the IXth Mandal of the Rigveda.

Marshall has written a short note on the perforated vessels found at Mohenjo-Daro: “This type of ware is found in considerable quantity at Mohenjo-Daro, but it is invariably broken owing to weakening due to the perforations. It is noticeable that these vessels are tall and cylindrical in form; dish-like specimen are rarely found. Despite the extreme roughness of their make, they were all shaped on wheel, as is shown by string grooving on their bases. They are generally made of porous paste which burns red in colour and which sometimes contains a little lime or sand, or both. Occasionally they are coated with a cream slip. They are common in the intermediate as in the late period.

Holes vary slightly in size to suit that of the vessel. They were made by pushing a stick through the damp clay from the outside, and thus a burred edge is left on the inside of the hole. As a rule the stick was pushed in at right angles to the jar (surface), but on occasions the work was carelessly done. In most cases holes of a larger size were punched in the base, the arrangement being a large central hole with number of small holes around it.

No. 9 and 11 are very roughly made by hand with very thick sides. There is one large hole in center of the base and number of smaller holes is arranged in a single row around the sides. Both were found in Block 3 of the Southern Buildings section, the first at 18 feet and second at 16 feet below the surface.

These vessels I would regard as heaters rather than strainers. Similar ware is a common feature of the ancient pottery of Babylonia, especially in the very early times, though it does not resemble that from Mohenjo-Daro in shape. It has been suggested that these jars were used in Babylonia for straining milk, which seem to have been an important item of diet amongst the Sumerians, but our examples can hardly have been used for this purpose." (Marshall 1931: 313)

Marshall has referred to Aurel Stein's comments on the similar pot in the note on the same page: "Sir Aurel Stein has found identical utensils at some of the Chalcolithic sites of Makrân. A large, complete vessel of this kind was found on a site near Awârân, containing remains of charcoal and ashes. It seems probable; therefore that perforated vessels of this kind were used for heating and perhaps for cooling." (Note 1, Marshall 1938: 313) Since Marshall has made his comments, many others researchers have speculated about the probable usage of these types of perforated pots.

Wheeler reported a specimen, only one of its kind found at cemetery R37 at Harappa: "Type R31– XLIV (Mackay Type Af), one example, is a tall cylindrical perforated vessel with an everted rim and a large circular hole in center of the base. It is characterized by two prominent grooves round the neck. The holes round the body have rugged or blurred edging, made by pushing stick through the sides while the clay was still wet. Only a single example was found in R 37, though this type in various sizes is common in the habitation areas both at Harappa and Mohenjo-daro." (Wheeler 1947:115).

Manchanda has taken review of the perforated vessels found by the time she completed her Ph.D. thesis. She has noted variations in shapes and modifications like rimmed jar, grooves, and bulging in the body etc. (Manchanda 1969:131-136). She points out that the perforated vessels are not peculiar to Harappan Culture only. In fact, these have been found at the pastoral-cum-agricultural sites of the Neolithic-Chalcolithic cultural of India and outside. Perforated potsherds are found at locations in Piklihal, Prakash, Ahar, Navdatoli, Chandoli, Sonepur, i.e. indicating widespread use of the perforated vessels. But no complete specimen had been excavated by then. Those specimens were mostly hand made gray or red ware. Also one more important variation was that these were pierced from inside leaving rugged edges on the outside. Thus hand-made perforated bowls were used primarily for milk preparation by the Neolithic people as suggested by Allchin (1960:45). Following the earlier suggestions Manchanda suggested that those perforated vessels could be used as ritualistic incense burner on the analogy of the use of such vessels in south India or simply as brazier as suggested by Stain. They could also be used as lamp shades with a wick or candle burning inside while central hole was used for mounting them on a stick or stand. Manchanda has given the instances of perforated pots from the ancient sites of Tepe-Gawra, Ur in Jamdet Nasr period, From Jamdet Nasr itself, etc. and mentions that they all served as strainers or colanders which could not be so equivocally vouched for tall cylindrical perforated vases of the Harappa type. (Manchanda 1969: 131-136).

Paddaya mentions that the perforated pottery is of common occurrence at the Neolithic sites of southern Deccan in extremely limited quantities and fragmented potsherds are found at those

sites. Their exact usage is uncertain. However he has suggested another use for the flat and walled plate type of perforated pot from the usage he witnessed in a village Pamulapadu in Andhra Pradesh. He mentions three uses of the perforated pot as suggested by Allchin, namely a) as braziers for burning essence; b) as cover or lid for milk boiling; and c) for steam cooking of cereals. He has given the procedure for making a paste of cereal; great millet (Holcus sorghum) by pounding it and mixing it with water and raw sugar. The walled flat perforated pot is placed on the pot of boiling milk and a lump of paste is placed on it and pressed with fist to pass through perforations. They form macaroni like tubular pieces ranging from 3 – 7 cm in length and get cooked. The delicacy so obtained is called Palatalikalu (milk tubes) in local Telagu dialect. It is enjoyed on festive occasions. (Paddaya 1969:450-453)

Ratnagar mentions in connection with the long perforated jar, "Among the shapes are tall, flat based and straight sided jar with large perforations through the walls. Some suggest it was meant for catching fish, others that it was used for burning aromatic substances (Ratnagar 2001:65)

McIntosh has given a beautiful photograph of a perforated jar from Harappa and she comments: "A distinctive Indus pottery type, the perforated jar; this example comes from Harappa. Such jars are usually found inside large bowls, a combination perhaps used as brewing equipment, with the perforated jar, wrapped in cloth, serving as a strainer." (McIntosh (2008:312) However it is to be noted that in the original reports of excavations of the I C sites quoted here in this article, I have not come across any mention of these pots being found inside larger pots.

The suggestions for the use of the perforated pot are summarized as:
These perforated pots could be used

1. As heaters or braziers,
2. For burning aromatic substances,
3. For milk boiling to cover the boiling pot,
4. For making macaroni like food item from sorghum paste,
5. For catching fish,
6. For brewing say wine etc.

SOME OBSERVATIONS

During my visit to Shikarpur in February, 2009. Drs. Ajithprasad and K. Krishnan were conducting excavation at the I C site close to the highway. Initially Dr. Ajithprasad took me round the site and explained the sequence of excavations and possible lay out of the ancient site. In one trench being excavated there were several pieces of perforated pot, broken pieces of possibly the same pot (Picture 2). It appeared to be a fairly large pot.

Then we went to the pottery yard here potsherds from various levels were segregated and marked with location and level. It was there I noted presence of the perforated potsherds in majority of potsherd heaps. I observed that many of the heaps contained nearly 5 – 8% pieces of these perforated potsherds. At that juncture it was not possible to correlate the occurrence of perforated potsherds with the type of set up, like household, open space etc. but that needs to be taken into

consideration in the future explorations. Considering the occurrence of these potsherds in large numbers and based on subsequent experiments on the perforated pot similar to picture 1, I propose that these pots were used in fairly large numbers by the people of the I C times as domestic coolers for the perishable food items. As mentioned earlier, these perforated pots were located in the residential areas. This supports the proposition of domestic usage.

Picture 2

Trench at Shikarpur where large collection of perforated potsherds was found

For long time I had question in my mind about the significance and use of these type of perforated pots (See Picture 2). With encouragement and active support from Dr. K. Krishnan who made the Vernier caliper, profile marker, foot rule, etc. available, I was able to measure the various dimensions of the potsherds of the measurable size, although small pieces were in abundance. Measurements of the potsherds are summarized in Table 1: The potsherd in sample 10 appears to be a mini perforated pot as it is given in Picture 3.

Table 1: Perforated Pots Measurements

SR. NO.	POTSHERD LOCATION MARKS	DEPTH MARKED ON THE POTSHERD	OD OF POT IN CM	THICKNESS OF POT MM	FRONT OD OF HOLES MM	BACK OD OF HOLES MM	CENTER TO CENTER MM	ROUGH SIZE OF A POTSHERD CM X CM	REMARKS
1	FP 3 (3)	1.15+55 CM	25	10	6.0-6.5	6.0 – 6.5		5 X 7	HOLES SLIGHTLY INCLINED
2	FP 3 (5) SAMPLE 1	1.15+110 CM	24	15	6.0-6.5	5.0 – 6.0		5X8	HOLES SLIGHTLY INCLINED

3	F P 3 (5) SAMPLE 2	1.15+110 CM	18		6.0 - 7.0	5.0 – 6.0		6.5 – 13	H O L E S A L M O S T VERTICAL
4	EM 12 (3)	3.17+102 – 130 CM	29	11	5.0 – 6.-0	4.0 – 5.0		6X9	H O L E S INCLINED
5	FM 12 (5)	4.6, 4.66 CM	35 CM	10	5.0 – 6.0	3.5 -4.0		4.5 X 7	TRIANGUL AR SHAPE 7 CM HT
6	EM 16	3.19+033 CM	5 5 (N O T RELIA BLE)	14	7.0 – 9.0	6.0 – 8.0	15	5X5	H O L E S SLIGHTLY INCLINED
7	EM 13 (2)	3.24+24-44 CM	20	12	7.0	6.0	15	7X4.5	H O L E S SLIGHTLY INCLINED
8	EM 13 (2)	3.28+55+66	29	13	6.0 – 7.0	4.0 – 5.0	15	4X6	P O T O F F I N E QUALITY
9	EL 16	2.62 + 89-91	26	10	7.0 – 8.0	6.0	14 -16	4X6	H O L E S A L M O S T VERTICAL
10	FP6 FK13	BUICK (1)	6 TO 4	12	3		12	6 X3	F E M A L E TOY
11	FKP 09	4 1 1 + 1 . 0 6 -149 CM	15	11	6.0 – 7.0	4.0 – 5.0	12 – 20		H O L E S RAMDOM
12	EN 15 (2)	2 . 3 7 M + 8 0 CM	20	12	7.0 - 8.0	5.0	12 – 13	6.5X5	H O L E S VERTICLE
13	EM 13 (6)	120 -125 M	22	7	6.0	5.0	12 - 13	3X5	VERTICLE HOLES
14	FK 13	49+168CM	14	11	4.0 – 5.0	4.0		IRREGUL A R CIRCULA R	B O T T O M C O R N E R PIECE
15	EM 12 (6)	4.47M+50-60 CM	22	10	3.0 -4.0	2.0 – 3.0	7.- 8	IRREGUL AR	
DIMENSIONS OF A POTSHERD MEASURED AT KANMER									
16	KANMER	LOT 1031		15	11 – 12	10 – 11	23 -29	6.5X6	

Picture 3

Broken piece of mini perforated pot where dia. of holes inside the pot is too small to be measured

Earlier I had proposed that the female figurines found in I C were the dolls for the female kids of those times (Pathak 1991:57-65). Here I propose that the small perforated pot with bottom OD of 6 cm and top hole of 1.5 cm ID could not be used for any other purpose than just a toy used by a female child in a family. So on the lines of proposing that the dolls found in the excavations at the Indus sites were toys for female children, similarly these small sized perforated pots were toy coolers of these times like toy freezes of today.

A few kms away from Shikarpur, Dr. Jeevan Kharakwal of Department of Archaeology, Institute of Rajasthan Studies, Udaipur, was conducting excavation at a historical site at Kanmer. In the lower levels at the site, the remains of I C were discovered. I had opportunity to visit the site with Dr. Krishnan. There too I found the perforated potsherds in many heaps. Picture of a gong like perforated potsherd found at Kanmer is given in Picture 4:

Picture 4

Saucer like perforated potsherd found at Kanmer. Dimensions of the Kanmer saucer like potsherd measured on the spot:

Kanmer Potsherd lot 1032B

Top dia of the potsherd	150 mm
Bottom dia of the potsherd	83 mm
Height of the wall	45.2 mm
Hole dia on top	7.4 – 7.6 mm
Hole dia at bottom	7.8 - 8.0 mm

EXPERIMENTAL ARCHAELOGY ON POTTERY

James Skibo was involved in ethno-archaeological investigations in the Kalinga people in the Pasil River valley at Guinia-ang in northern Luzon area of Philippines. He conducted some experimental trials on the pottery usage in the village (Skibo 1992). I came across this book during literature survey at the Deccan College library after I conducted experiments at home. Since my observations and logic are supported by his findings, I am quoting Skibo to press for the relevant observations on the I C pottery.

Skibo defines: "Experimental archaeology is the fabrication of materials, behaviors, or both, in order to observe one or more processes involved in the production, use, discard, deterioration, or recovery of material culture. It is theoretically identical to ethno-archaeology, because both sub-fields focus on the interface between material culture on the one hand, and human behavior, organization, meaning and environment on the other. Moreover, both ethno-archaeology and experimental archaeology have the same objective: understanding the past by addressing questions with modern day material culture." (Skibo 1992:18).

Skibo further mentions the same sentiments I had experienced after I returned back from Shikarpur and Kanmer visits which motivated me to go for experimentation, "Experimentation, like ethno-archaeology, makes a comeback when archaeologist begin to be dissatisfied with mere classification and description. In fact, some of the same individuals had advocated a renewed interest in ethno-archaeology for explanation in archaeology also saw the importance of determining how artifacts were used." Skibo quotes other scholars, namely Julian Steward and Frank Setzler (Function and Configuration in Archaeology, American Antiquity vol. 4:4-20. Quoted from page 8) as "archaeological objects would be more meaningful if they were regarded not simply as museum specimens but tools employed by human beings" (Skibo 1992:19). Another very important observation he makes is, "A primary feature of controlled laboratory experiments is replicability. Researchers anywhere should be able to acquire the same materials, perform the experiment and attain identical results. The results of a controlled laboratory experiment should be in the form of general principles that explain and describe the relationship between a technological property of a material item and the same behaviorally meaningful unit." (Skibo 1992:21-22). It was exactly the same motivation that made me to go for making the perforated pots and experiment with the edible items as described below.

Based on the actual usage by Kalinga people, Skibo gives the alterations that can occur in the pottery, what he terms as ceramic alterations: "Ceramic alteration includes all changes in the ceramic (surface or subsurface) resulting from physical or chemical processes that cause either the addition, deletion or modification of material."

Based on the actual observation of usage, Skibo has given the following marks likely to occur on the earthen pot under usage by the people. i.e. family utensils.

SKIBO's CERAMIC ALTERATION FRAMEWORK

Example		
	Use alteration	No-use alteration
Carbon deposits	Charring of food Sooting from fire	Charring or sooting from unintentional fire
Organic residue	Content of vessel	Organic matter from soil
Attrition	Mechanical action of pottery use, non-mechanical action such as salt erosion or thermal spalling	Fluvial abrasion, freeze/thaw breakdown

Proposed usage examined

After knowing the dimensional details of the pots from the Shikarpur site, I tried to analyze the proposed usages summarized in earlier sections:

1. **Use as heater or brazier**: The possible scenario could that burning coal with little ash is placed inside the perforated pot as source of heat for heating room. The repeated use as heater should result in permanent burning mark on the vessel from inside. In all the samples I observed and handled both at Shikarpur and Kanmer, not a single potsherd carried a burning mark. And as a Chemical Engineer having worked on the high temperature exfoliation of vermiculite at temperatures of about 1100 -12000C, I have my own doubts on the efficacy of 7 - 15 mm thick walled perforated pots as room heaters on account of temperature drop across the wall thickness. But before coming to conclusion I would like to perform experiments taking the surface temperatures and finding the extent of radiation heat loss, which I did as a chemical engineering professional. Let me not rule out the possibility even in absence of potsherds any burning or vitrification marks. Although Aurel Stein has reported perforated pot filled with charcoal and ash from the coastal area of Makrân, the marks of burning or vitrification from inside are not reported. So also it is little difficult to believe that people living in the coastal areas of Makrân needed room heaters or braziers to that extent. The same could be the case for people living in Kachchh area. It is also to be noted that over a period of say few hours, coal ash needs to be blown, and then only the pot could be effective. In a pot which is 25 -30 cm tall, it will be difficult. However this needs experimental verification. Usually the heaters and braziers are moved from one location to other, say from room to room. In that case large bottom hole with small holes on wall become unsafe for carrying.

2. **For incense burner**: Usually the incense burners are shallow pots with a handle. As the traditional use in Indian houses or in the places of worship. These are usually taken around while air is blown over the surface for proper and complete burning of the aromatic material. Aromatic material is not allowed to burn but to generate scented smoke. A semicircular bowl reported from Lothal has pedestal and few holes at the bottom could have been used for the purpose of burning aromatic substances. Just because it has holes at the bottom round portion, it can't be called as perforated pot. Secondly, being subjected to both burning coal and smoke, it should carry burning marks soot deposits on the wall. These are not reported. It should now be re-examined. But it could be used as a strainer by just covering the bottom holes with say sheep wool; it could be used for straining Soma juice with pulp. But bowls of this type are very less in number. Most of the potsherds I measured point to being cylindrical shaped rather than part of the hemispherical bowl. It is also difficult to perceive the tall jars being used as incense burners because most of the smoke will get trapped in the perforations. It would not serve the very purpose of spreading aroma around. The Large perforated pots also weighed heavy and had holes at the bottom. These could be difficult to move around as is the usual practice.

3. For milk boiling to cover the milk boiling pot: The only specimen which meets thisproposition is form Kanmer shown in Picture 4. But the specimens of this type are rare while boiling milk could be a very normal activity. I anticipate that every house hold could have such lids there by reflecting in occurrence in large number. Also the edges of the lid being subjected to soot from the burning firewood, should carry some soot marks. When I checked the piece at Kanmer, it was very clean and showed no marks of soot etc. But my focus was on the perforations and dimensions so I could have missed it. If the perforated lid like this could have been effective in preventing boiling milk from overflowing, ladies especially in India could have continued it usage. But nowhere in India milk boiling is carried out in a vessel covered with perforated lid. Not even the professional confectioners, sweet makers, i.e. 'Halwai' use this type of lid for the milk boiling pot. The potsherd should be examined in light of the present discussion. Another reason to rule out this usage is the cleanliness of the pot. The boiling milk would get absorbed and stick to the perforations and difficult to clean. Very soon it could be spoiled and when used next time it would infect good milk coming in contact. Indian ladies and confectioners scrupulously avoid bringing good milk in contact with soured milk traces for the obvious reason that it could spoil the larger lot.

4. For making macaroni like food item from sorghum paste: As suggested by Paddaya, the only candidate for this type of usage is the item in Picture 4. The tall perforated pots do not meet this requirement. But the author has suggested an alternative use for this type of lid like perforated shape.

5. For catching fish: Tall perforated pots could be used for catching fish as proposed by Ratnagar. But there are two difficulties that come in the way of accepting it. First and the foremost is the weight of the pot. 10-15 mm thick pot after absorption of water would become too heavy to be handled in water. For catching the large fish in the flowing stream, the fishermen

use net, which has larger area coverage for fish to get trapped. Compared to that mouth of 20-25 cm diameter is too small for effective catch.

6. For brewing say wine: McIntosh has proposed this usage. She also states that these perforated pots were found in larger pots. I have not come across such a description in the excavation reports, so also Manchanda who has given many details of the perforated pots too has not mentioned it. So it is speculative. The possible scenario based on the suggestion by McIntosh is that the perforated pot is kept in larger earthen jar filled with water. The mash for digestion and fermentation is kept inside the perforated pot. It would form heap. The mash filled perforated pot then kept inside the larger pot to complete brewing. Looking at the occurrence of pot, it is inconceivable that almost every household would have a brewing pot.

I have doubts whether 30-40 cm thick heap of mash stacked in perforated pot will ever give proper yield of alcohol. It needs to be experimented. In the current legal framework, it will need permission from the Central Excise Department of Government to officially conduct the brewing experiments. It will also be expensive and will need financial support.

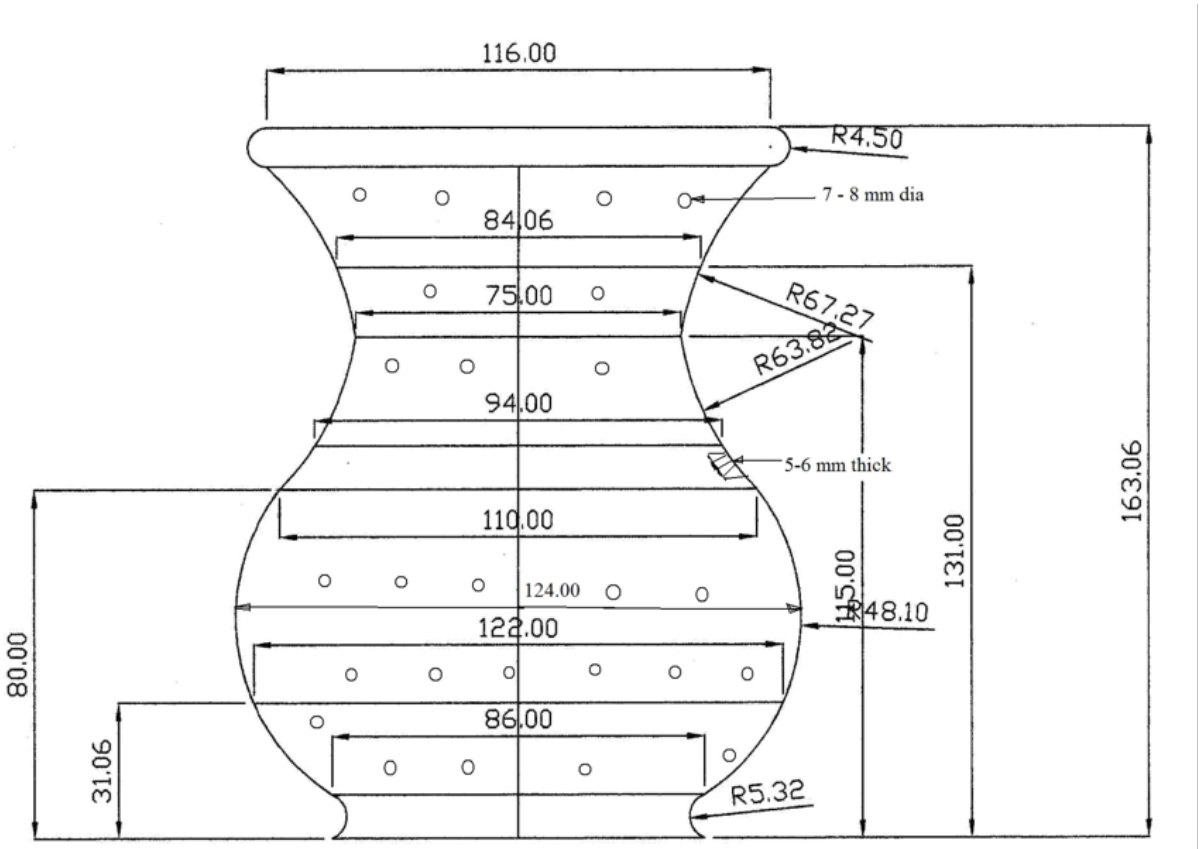
To sum up, all the possible uses of the perforated pots suggested so far do not satisfy the actual observations from the potsherds that:

a) The majority of the perforated potsherds are part of the tall cylindrical jars,
b) They are clean with no traces of vitrification or burning marks and soot deposits,
c) They have no black or colored spots to indicate usage as brewing or lid for milk boiling etc.,
d) The inside projections in the samples I observed were fairly intact and the rough surface in the original form indicating that the usage did not need cleaning the inside surface applying say hand pressure leaving also abrasion marks. But this needs to be confirmed by examining several more potsherds and from many locations. It is to be done by the respective excavating institutions re-examining the potsherds excavated.
e) A large hole at the bottom with smaller holes around it indicates need for bottom discharge. It rules out the use as heater as it would become unsafe to handle.

All these observation raised many questions in my mind. It prompted me to go for actual experiments on the perforated pots as described below.

MAKING PERFORATED POTS

After visit to Shikarpur and Kanmer, I went to Ahmadabad where I gave drawing of the small sized perforated pot to a local potter. He made two sample pots for me. The dimensions of the small pot used for the experimental purpose are given in Fig. 1 (Small perforated pot used for experiments).



Dimensions of small perforated pot

After returning to Nasik I contacted a local potter and give him drawing of larger perforated pot. He initially expressed inability to make such a thick pot of 10 -12 mm. Finally after bit of persuasion he agreed to make pots of the larger size but of less wall thickness. I had to do follow up constantly and visit the potter's site. After about a month and half he gave me four pots which were nearly identical. He conveyed me the difficulties he encountered specially while making perforations. He made holes in pots after these were semidried. Out of seven pots he made three were broken while piercing holes. Dimensions of the larger pot are given in Fig. 2.

It is to be noted that while thickness of the I C potsherds ranges between 7 mm to 15 mm, the sample pots are 5 to 6 mm thick. The potter expressed inability to make thicker pots because he was not sure of the drying time and confident of making holes. I was interested initially to get at least a few pots made for experimental purpose on trial basis as early as possible. When he made the pots, he did not make holes at the bottom. That is a major shortcoming which I propose to rectify in the next set of pots.

EXPERIMENTS WITH PERFORATED POTS

I received set of two sizes of perforated pots around first week of April. I was planning to conduct some type of filtration experiments in the pots based on Mahadevan's hypothesis for

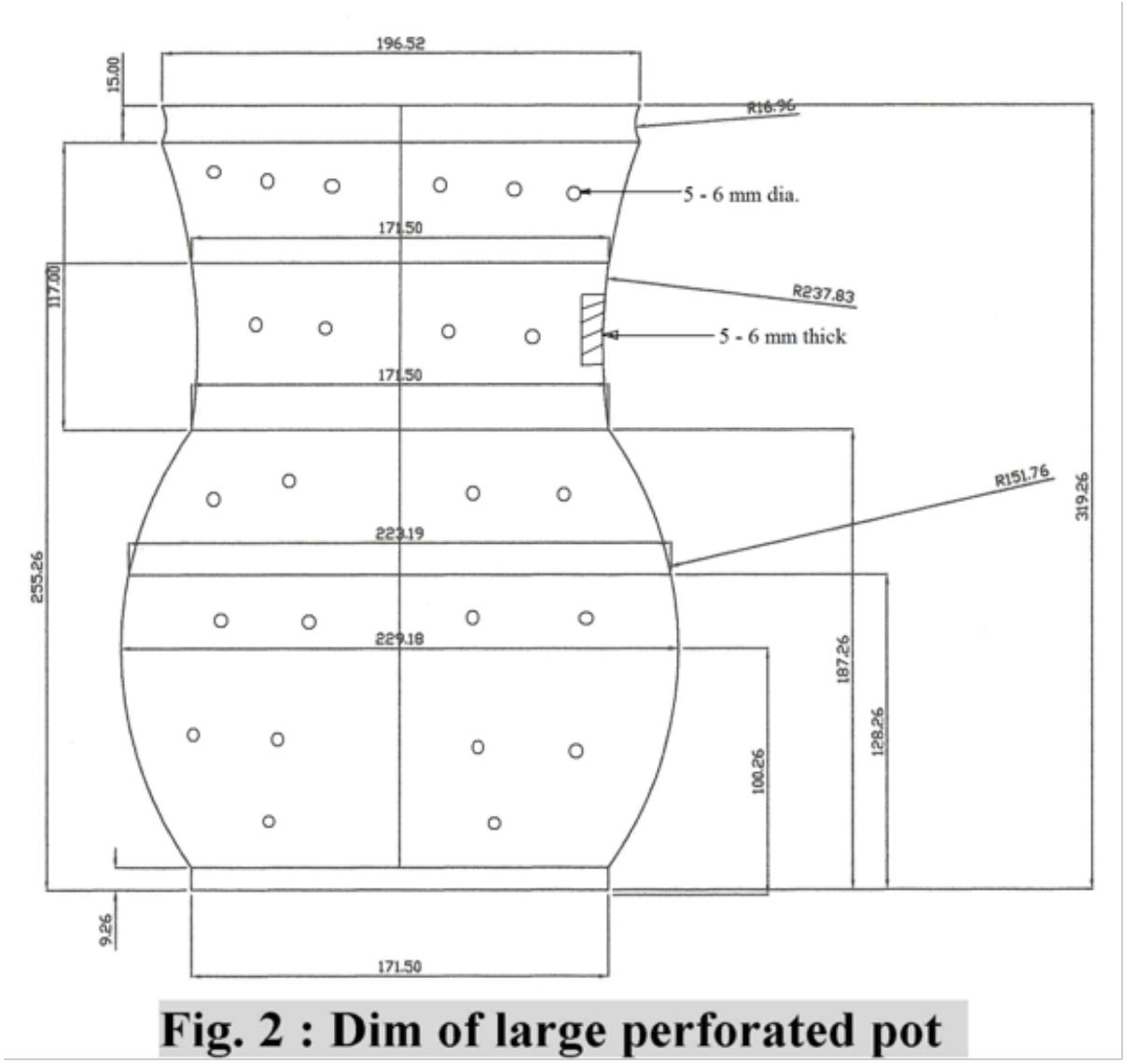


Fig. 2 : Dim of large perforated pot

using the pot for straining the Soma juice. However the pots shown on the sacred bull - Ekavrisha - seals (Pathak 1999:38-45) are hemispherical. The above set of tall perforated pots could not hold wool properly for filtration and so I was planning to use a cloth bag fitting the shape inside.

As it is usual practice, whenever we purchase an earthen pot for use in the summer time to get cold water, we soak it 2-3 times and wash it before putting in use. This is done to remove the burnt clay odor. I thought of doing the same with these pots too. As I dipped the pots in a bucket filled with water. There was lot of bubbling indicating porosity. I allowed the pot to remain in water for 25 -30 min till no more bubbling observed. Then I kept these on the kitchen platform to let the excess water to drain. After about half an hour I checked for complete draining of water. Draining had stopped. I lifted the pot. I felt it much colder that surrounding. It gave me clue that in the I C period, these perforated pots could have been used as coolers for perishable household items. I procured a thermometer measuring up to 500C and experimented with various

vegetables and Buttermilk. I experimented with the solid vegetables like alibanam (Coccinia cordifolia) (Tondale in Marathi), French beans (Phaseoluse vulgaris), bitter gourd (Momordica charantia), leafy vegetables spinach (Palak) (Spinacia oleracea) and mint (Pudina) (Mentha Spicata). I conducted two experiments with Buttermilk.

Experimental description

Every time I conducted experiment, I used to soak the pot in water till bubbling stopped. It took about 15 – 20 min. Then I put vegetable in the perforated pot and added water from the top and ensure that the vegetable inside was fully wet and water flowed through the holes. The top of the pots was covered with a ceramic saucer. Then I let all the water to drain for 10 -15 min and start taking readings with thermometer. See pictures 5 & 6 of the experimental set up.

Picture 5

Picture 6

Since there were no holes at the bottom, some water was held in the depressed part at the bottom. In case of experiments with Buttermilk, I took two identical pots of a stainless steel Tiffin box, took equal quantity of buttermilk from the same lot and put one of the pots outside and one inside the large perforated pot. Then I measured the temperature of buttermilk in both the pots at intervals. Results of the experimental measurements are listed in tables. See pictures 7 & 8.

Picture 7

Picture 8

Experiment 1
Date 4th April 2009
Small pot used. Vegetable used Alibanam, about half kg

Table 2

Sr. No.	Time of reading ^{0}C	Ambient temp. ^{0}C	Temp. inside ^{0}C
1	11.45 AM		26.5
2	12.10 PM		23.0
3	12.30 PM		21.5
4	01.15 PM	31.0	20.0
5	02.00 PM		19.8
6	03.15 PM		19.8
7	04.15 PM	29.5	20.4

It was observed that the temperature of the vegetable actually went down as the time passed till 3.15 PM.

Experiment 2
Date 14th April 2009
Experiment with buttermilk

I took buttermilk in two identical stainless steel pots. One pot was kept outside and other pot was kept inside the perforated pot.
Table 3

Sr. No.	Time of reading	Ambient temp ^{0}C	Buttermilk temp in outside pot ^{0}C	Buttermilk temp in inside pot ^{0}C
1	09.00		19.5	19.5
2	09.10		20.5	20.0
3	09.20		22.0	20.5
4	09.30		23.0	21.0
5	09.45		23.5	21.5
6	10.00		24.5	21.5
7	10.20	27.5	25.0	21.5
8	10.50		25.5	21.5+
9	11.30	28.5	26.0	21.5+
10	12.30	29.0	27.5	21.5+
11	14.05	29.0+	28.0	21.5+
12	15.20	29.0+	28.9	21.9
13	17.00	29.5+	29.2	22.0
14	19.00	30.0+	29.5+	22.0+
15	20.10	29.5+	29.0+	23.0
16	21.00	28.5+	28.5+	23.0+

Experiment 3
15th April 2009
Experiment with French Beans in larger pot
Experiment started in late morning when the ambient temperature in room was 290C
Table 4

Sr. No	Time of reading	Ambient temp ^{0}C	Temp inside pot ^{0}C
1	12.30	28.5+	24.0
2	13.15		25.0
3	14.35		23.5
4	16.07	29.5+	23.5
5	18.35	29.0+	23.0+
6	19.50	28.5	23.0
8	21.15	28.5	23.0
9	22.30	27.5	22.5+
10	04.50 (16th Apr)	25.0+	23.0

Experiment 4
21st April 2009
Experiment with leafy vegetables at Night
Table 5

Experiment carried out in night time on leafy vegetables. A spinach bundle was soaked in water and kept in open in a dining dish. Another bundle of roughly same size was soaked in water and

Sr. No.	Time of reading	Ambient temp. ^{0}C	Spinach temp in open dish ^{0}C	Temp of spinach in larger pot ^{0}C	Temp of mint is smaller pot ^{0}C
1	21.15	28.5	24.5	23.5	23.0
2	22.30	27.0	24.0	21.5	23.5
3	02.30 16th Apr	26.0	23.5	19.5	21.5+
4	05.15	24.5	23.5	19.0+	20.0+
5	06.35	24.0	Spinach bundle appeared to be dry and stale so removed.	20.0	21.0
6	08.55	25.5		19.5+	21.5

inserted in larger perforated pot and a small bundle of Mint was soaked in water and inserted in small perforated pot.

In the above experiment the spinach bundle kept in open dish appeared to be stale by morning, so it was removed around 6.30 AM. The spinach and mint bundles in the perforated pots, middle and right respectively (Picture 8) were taken out at 09.00 hrs. Both were looking fresh.

Experiment 5
30th April 2009
Experiment with Bitter gourd
A kilogram weight of Bitter gourd was kept inside the big perforated pot fully soaked in water. Water was added to the pot and let to drain and then temperatures were taken.

Table 6

Sr. No.	Time of reading	Ambient temp. ^{0}C	Temp of bitter gourd inside pot ^{0}C
1	13.00	29.5+	28.0
2	14.15		25.0
3	16.30	31.5	24.0
4	17.15	29.0	24.05
5	07.15 0n 1st May	26.0	24.0

Experiment 6
Date 2nd May 2009
Experiment with buttermilk
Buttermilk experiment to check the temperature rise from lower temperature. Buttermilk from freeze at 7.00C was taken for experiment. It was kept inside the large perforated pot soaked in water. Idea behind this experiment was to simulate the conditions in desert region where the night temperature falls to less than 100C and rises to 35.0 – 37.00C during the day time.

Table 7

Sr. No.	Time of reading	Ambient temperature ^{0}C	Temperature of Buttermilk ^{0}C
1	07.30	24.0	7.0
2	07.42		8.5
3	07.55	25.0	10.5
4	08.07		12.0+
5	08.25		14.0
6	09.05	27.0	17.0
7	10.10	27.5	19.0
8	11.20	29.0	19.0
9	13.45	30.0	19.0
10	16.0	30.0+	19.5
11	17.0	30.0+	20.5
12	18.22	30.0	20.5
13	19.50	29.5	21.0

Above experiment indicates that the items can be better preserved if kept inside the perforated pot at lower temperature. It could have been the routine in the ancient times to let the edible items to cool at night and keep these inside the perforated pot early morning.

Experiment 7
Date 2nd May 2009
As extension of above experiment 6 the following experiment was conducted overnight. A bundle of Mint leaves was kept in larger perforated pot and about half a kilo of Alibanam was kept in the smaller perforated pot. Both the pots were fully soaked in water.
As both the perforated pot appeared to be dry from outside, water was sprinkled. Some water seeped inside of the pots.

Both the pots were dry from outside at 9.30 PM. When the vegetables were taken out, Mint leaves were wet and appeared fresh. Alibanam was completely dry but it also appeared fresh. It is felt that sprinkling of water around 13.00 hrs could have helped to preserve temperature around 22.00C.

Sr. No.	Time of reading	Ambient temp ^{0}C	Temp of Mint leaves inside the large pot ^{0}C	Temp of Alibanam inside the small pot ^{0}C
1	20.15	26.5	27.0	26.5
2	21.40	27.0	25.0	23.5
3	22.30	27.0	23.0	22.0
4	03.30 3rd May	26.0	22.0	22.0
5	05.00	25.0	22.0	22.5+
6	06.05	25.5	22.0	----
As both the perforated pot appeared to be dry from outside, water was sprinkled. Some water seeped inside of the pots.				
7	08.15	26.5	22.0	21.5
8	11.00	28.5+	21.5	21.5+
9	12.45	29.0	21.0	21.5+
10	15.00	-----	21.0	23.0
11	16.45	31.0	21.5+	24.0
12	21.30	28.5+	26.0	27.0

The saucer like perforated plate from Kanmer (Picture 4) could be used as cover or lid for the tall jar. In wet condition it could be effectively used to maintain lower temperature inside the pot. In my experiment I used to cover the smaller as well as larger pot with ceramic saucers. I could not get that type of lid from the local potter.

CONCLUSIONS

1) The experiments are indication for possible usage of the perforated pots in the I C period. The large opening at the top facilitated easy access and ease of removal of the material.
2) The temperatures of the items kept inside the pot show tendency to reduce in the beginning.
3) The temperatures of the items inside the perforated pot are observed to be at consistently less than the ambient temperatures.
4) Perforations over the entire height of the pot help inducing upward the draft of air.
5) Lowering of temperature inside the perforated pots can be explained by Air draft. Air gets cooled while passing through the pores. Soaked water evaporates and latent heat of evaporation drawn from air flow and vegetable item. It results in cooling of material inside.
6) Water sprinkled on vegetables also evaporates to keep the temperatures lower.
7) Lower temperatures can be maintained by frequent sprinkling of water at a few hours of intervals.
8) Vegetables, especially leafy vegetables, remained fresh inside the perforated pots for longer period.
9) Presence of very large numerically large number of perforated potsherds indicated large scale use, so much so that at many locations every tenth or twelfth pot could be perforated pot of larger size.
10) It is felt that thicker pots of 10 -15 mm could give lower temperatures for longer interval. It needs to be verified. (Any takers for the idea?)

Scope for further work

a) The perforated pot made by the potters are not exactly as per the ancient potsherds, since the firing technique differs. While the ancient potter must have used the dry wood or plants for firing, the modern times potter at Nasik used rubber tires for firing. The texture of the modern perforated pots certainly differs from the ancient potsherds, so also the thickness. The pots made for experiments are thinner compared to the potsherd thickness in table 1.

b) Thicker pots of 10 – 15 mm thickness as per the ancient I C potsherds could give lower temperature profile inside the perforated pots compared to the thinner pots used in the current experiments. These need to be verified.

c) The perforated saucer like cover as shown in Picture 4 could be used for covering the perforated pots. It was not available for the current set of experiments. These may give somewhat different temperature profile, may be on the lower side.

d) The thermometer used for these experiments is less accurate and could not be used for taking the temperature gradient across the height of the stacked vegetable. Modern digital temperature indicator with multiple measuring points can give more accurate results with temperature profile.

e) In personal communication with Dr. Pramod Jogalekar, paleo-biology expert from the Deccan College at Pune, he indicated the fish bones of the salt water, namely sea born fish are found at the Indus sites much deeper inland locations. Transport of fish far away from sea port could not be explained so far. With the indication of cooling possibility, fish transport can be experimented in thicker pots. Experiments can be performed for fish preservation and transport. However as Dr. Krishnan pointed out the fish bones may have come from a dry fish which is one way of conserving fish as a food item even today.

f) Wheeler has indicated that these perforated potsherds and pots were found in the habitation areas both at Mohenjo-Daro and Harappa. This observation can be further confirmed by checking the potsherd locations available with various archaeology departmental collections. It could be verified whether the locations at which these potsherds found in large numbers, to the extent of 5 - 8 %, are the domestic locations and then whether these were used by women folk of I C period as domestic coolers for edible items. Since the potsherds I have checked did not carry the heating or soot marks, not abrasion marks, the most probable use was coolers.

g) At locations close to ancient sea shores like Shikarpur, where fish catching could be a regular business, the perforated potsherds in large numbers can verify the proposition by Dr. Jogalekar

h) There is need to verify effectiveness of the perforated lid in giving lower temperature profile inside the perforated pot. The archaeologist community can surely go for more elaborate and detailed experimentation with the expert manpower and technical and instrumental resources at their disposal.

i) These experiments can also be performed at the I C sites to verify the results.

Acknowledgements
I sincerely thank Drs. Ajithprasad and K. Krishnan who invited me to the excavation site, allowed me to stay at the excavation camp at Shikarpur and actively encouraged to undertake perforated potsherd measurements. Their colleagues, Shri. Kantibhai Parmar and Rajesh Brahmabhatt too actively supported in my efforts. At Kanmer I received very good cooperation from Dr. Jeevan Kharakwal. Dr. Pramod Jogalekar is always a source of information and active participant in discussions. I gained a lot from him. Manzil hazarika got me Paddaya's paper ready on my table without which the literature search would have been incomplete. Staff at the Deccan College library are always cooperative. My son-in-law Shailesh Pandit got the drawings made on Auto Cad after measuring the dimensions with precise instruments. I thank them all. Without their active support this paper could not be complete. It is very formal to thank one's

wife. She is always by my side. With active support of my wife Usha, experimental work was done.

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Notes by Ajithprasad.

Dear Dr. Pathak,
Thanks for mailing the paper before publication.
I did enjoy reading the paper as I too had once tried to examine various possible use of the Harappan perforated jar. Your idea of they being used for keeping the vegetables, fruits etc., cool and fresh is certainly interesting. You have also shown, through a series of experimental studies involving different vegetable and food items, that the temp inside the perforated jar is lower than the surroundings. And the explanation that constant evaporation of water from the pot (the pot is soaked in water) resulting into lowering of temperature inside the pot is perfectly valid. However, I am not sure how hundreds of holes on the body can produce an air-flow draft inside. This needs more checking. There is also another factor here: the perforations effectively reduce the surface area, lesser the surface area lesser the rate of evaporation. What it means is that the cooling inside a normal pot without perforation would have been better than in a perforated pot. This fact also points out a major drawback in your experimental study. The experiments should have been conducted by using a perforated pot and a normal pot of identical features but with out perforation. This would first of all help to check the efficiency of the two vessels in keeping things cool and make the experiment more scientific. The present experiment gives only the expected result.

But there is one important aspect you may have to look at closely; that is, do perforations actually reduce the surface area available foe evaporation? My feeling is that they may not, because the cylindrical surface of each hole in effect probably doubles the area available for evaporation, like the modern automobile heat radiators. If that is the case, theoretically perforated jars will be more efficient in cooling than the normal jars. This needs to be demonstrated experimentally to be taken as a fact.

The other point I have some reservation is that even when we accept (through experimental studies) that these were essentially used for keeping edible things cool, some its features that looks out of sink with the use. For instance, the "cooling vessel" function does not convincingly explain why should all the tall perforated jars have a large hole in the center at the bottom? Was it just to drain extra water? Certainly such a large hole is not necessary to drain out water, especially when there are hundreds of holes all around including at the bottom. Was it functional? Was it not? Any plausible function of the vessel should be able to incorporate these features too to make it more convincing.

Some questions are always unanswerable. May be one day we may be able to answer that too.

Thanks for the good study.
Ajithprasad

Following are the details of the perforated jar in our Dept.
Site: Bagasra
Trench: Em13
Period: Urban Harappan; Phase II
Associated finds: found leaning against the fortification wall in a slightly slanting, vertical position. Probably within a dwelling structure with several clay silos that contained shell, and semiprecious stone beads as raw-material.
Details: Maximum height: 37.5cm
Rim diameter, external: 21.5cm
Rim dia., Internal / orifice: 17cm
Max. Body dia. Close to the base: 23.3cm
Dia. Of the base hole: 4.5cm

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