



Drip irrigation technology, originated from Odisha province of India : A review

P.K. PANDA^{1*}, R.K. SAMANTARAI², D. PANDA³ AND T.R. DAS⁴

¹ICAR-Indian Institute of Water Management, Bhubaneswar-751023, Odisha, India

²Ex-Joint Director, F&ARD Department, Govt. of Odisha, India

³Viswabharati University, Shantiniketan-731235, Bolpur, W.B., India

⁴ICAR-Indian Agricultural Research Institute, New Delhi-110012, India

*pandaicar@gmail.com

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ABSTRACT

Water resources are becoming scarce day-by-day, reducing their availability at various levels throughout the world. The per capita per annum water availability of India has also reduced from 5177 m³ in 1951 to 1450 m³ in 2022. To ensure water security for all, the water use efficiency (WUE) must be increased in every field by reducing wastage. WUE is the single most measurable parameter, which indicates whether there is judicious use or wastage of water. For enhancing WUE scientific, efforts have been made in various parts of the world in different time spans. Evidence has suggested that first attempt in the direction of enhancing WUE was made in India during *Satya Yuga*. Mythological evidence and religious traditions have proved that first invention of drip irrigation was made by Odia people in the Odisha province of India during the same period.

Key words: Drip irrigation, India, Odisha, originated, water use efficiency

INTRODUCTION

Water is the most important natural resource of the world, which supports life directly. Out of the total water resources, fresh water supports most of the living components of the ecosystem like human beings, animals, plants, microbes, and freshwater aquaculture. However, the share of freshwater in the total water resources of the world is only 2.7 per cent, compared to the 97.3 per cent saline water (Vision, 2030). It is again ironic that whatever fresh water we have, only 12% are useful to us, and the rest 88% remain in nature without having any use to the living world (Vision, 2025). It is estimated that about 77% of total fresh water is locked in permanent snow and glaciers and 11% of fresh water remains at a depth below 800 meters in the earth's crust, which is difficult to extract by using the present-day extraction technology. Another 11% of the freshwater remains at a depth within 800 m in the earth crust,

which is extracted by wells and submersible pumps and put to use. Approximately 1% of the total freshwater resources remain as surface water, in rivers, ponds, freshwater lakes, dams and ditches. The per capita freshwater availability in the world has been constantly decreasing over the decades due to rise in population. To meet various requirements of the burgeoning population, subsidiary sectors, like industry, transport, housing, domestic etc. are growing very fast and consuming huge quantities of fresh water. Among various sectors that utilize fresh water, the agriculture sector utilizes the lion's share world over. An estimate shows that by the year 2050, total freshwater requirement of India would reach to 1447 Billion Cubic Meter (BCM) against the present utilizable water resources of 1123 BCM. Since the total demand would exceed the total supply by 324 BCM, multiple challenges will emerge from various sides. During the same period, the agriculture sector will require a total of 1074 BCM fresh water which

is 74% of the total requirement (Kumar et al., 2013). It would be very difficult for India to spare this much for a single sector leaving the demands of all other sectors unfulfilled. However, to meet the requirements of the ever-increasing population, we must produce the required quantities of food and other materials. As the agriculture sector utilizes the highest quantities of freshwater compared to other sectors, there is an urgent need to enhance its use efficiency. The answer is to switch to the most efficient irrigation method, where wastage of water can be reduced for enhancing its productivity. Among various irrigation methods such as flooding, furrow, ring, pitcher, sprinkler, and drip, the last one is found to be the most efficient method. Drip irrigation saves huge quantities of water, enhances production, and enhances fertilizer use efficiency. Studies show that drip irrigation saves 50 to 70 % water as compared to furrow irrigation (Mandal and Jana, 2017). In the evolutionary process, uses or methods of water wastage reduction or efficient uses of water might have been developed for general purposes first and then those principles might have been applied in irrigation sector to save water. Efficient irrigation methods might have been invented much later dealing with watering crop plants.

CONCEPT OF WATER USE EFFICIENCY

Water is a vital resource which supports life, and its use efficiency has been calculated at different points of time by various workers for quantifying the exact loss to provide desired policy support for its sustainable use. Water use efficiency can be best described as the amount of water really used in the production process compared to total amount of water diverted for that production process. In other words, the higher the efficiency, the lower is the wastage component and vice versa. In agricultural research, some people calculate it as ratio of quantity of biomass produced over amount of water used (kg per m³) in that production process. In recent times the term water productivity is used which denotes quantity of biomass production per unit of water used (kg per m³ of water used). More recently, system water productivity comprising different enterprises is calculated and expressed as total monetary value obtained per unit of

water consumed (Rs m⁻³) which is also known as economic water productivity.

MYTHOLOGICAL ASPECT OF WATER USE EFFICIENCY

In Hindu religion, during churning of ocean of milk by the *Gods and Asuras* (demons), many valued things were discovered. Among them *Amrit* (nectar of immortality) *Parijat flower*, *Airabat elephant*, *Goddess Laxmi*, *Kumadhenu* (cow of plenty), *Madira* (Goddess of wine), *Kalpabriksha* (wish fulfilling tree), *Apsara* (celestial dancer), *Uchhaishrava* (celestial horse), *Panchajanya*, Vishnu's mace and magic bow, various gems, *Dhanwantari* (Physician of Gods), *Halahal* (poison) and many other items. (www.britanica.com). The valued items were distributed by Gods and Asuras. Neither of them was interested in taking the poison. The impact of the poison was so high that could have killed the entire universe. So, it was decided that all will approach *Mahadev*, the supreme Lord of the universe to get rid of this problem. *Mahadev* agreed and drank the poison and kept it in his throat. The poison was so powerful that it burnt his throat and changed the colour of his throat to blue. After this incident, Lord *Mahadev's* name changed to *Neelkanth* (blue throat). It generated high intensity heat and to nullify the impact of heat, he kept Goddess Ganga on his head to pour water on his throat for long time. To reduce the heat of his body and relieve pain, water is required to be continuously dropped to his body (www.hindunismfacts.org).

WHY WATER DROPS MADE TO DRIP ON SHIVALINGA

To reduce the impact of intense heat generated from the *Halahal* (deadly poison) in the throat of Lord *Shiva*, water needs to be continuously poured into the head of Lord Shiva. During those days water conveyance through pipe was not discovered. At the same time, it was difficult to keep *Shivalinga* wet by continuously putting water for 24 hours. Initially devotees might have to bring thousands of pots filled with water for this purpose. Later, they might have thought, if pots filled with water were hung over the *Shivalinga* and a tiny hole was made on the pot, then it will allow water to trickle for long period. When

the water in the pot disappears, again they will refill it. Later, to reduce the flow further, they might have used Kusa grass or Doob grass to plug the hole, which could have lasted for hours together. Even today, the popular belief is that if one does *Jalavisek* worship (pouring water on *Shivalinga*), Lord Mahadev is pleased and fulfills the desire and Hindus are doing it. The same practice is seen in Shiva mandir (Fig. 1). This was in *Satya Yuga*, the oldest *Yuga*, as per mythological calculation. As per mythology, the entire time span of this universe is divided into 4 Yugs such as *Satya Yuga* (38,91,102 BCE to 21, 63, 102 BCE), *Tretaya Yuga* (21,63,102 BCE to 8, 67, 102 BCE), *Dwapara Yuga* (8, 67,102 BCE to 3102 BCE) and *Kali Yuga* (3102 BCE to 4,28,899 CE) (www.wikipedia.org). Perhaps this is the first attempt in the history of human civilization where attempts have been made for prolonging water delivery from a limited supply and became successful. We can say that this was the first attempt in the world to prolong water release from a limited supply. In other words, this attempt can be considered as the first invented step or technology for enhancing water use efficiency by reducing wastage for a specific purpose.

DRIP IRRIGATION

As water resources are scarce, its efficiency must be increased at every user point. Various scientists have tried to enhance water use efficiency in irrigation methods in past centuries which led to invention of furrow irrigation, paired row irrigation, ring irrigation, pitcher irrigation, sprinkler irrigation and drip or trickle irrigation over wild flooding. Among all the methods of irrigation, water saving in drip irrigation has been calculated to be highest. Gustafson (1975) from Senegal reported 30% water saving in drip while Singh et al. (1978) reported 50% water saving in drip irrigation. Mandal and Jena (2017) reported that drip irrigation resulted in 40-50% water saving compared to furrow irrigation and 50-70% water saving compared to flood irrigation. Water saving approach of drip irrigation has also been found across all the soil types. In heavy soil units, 20-40% water saving has been noticed whereas in case of light permeable soil units, water saving varied from 50-70% (Goyal, 2013; Mandal and Jena, 2017).

HISTORY AND EVOLUTION OF DRIP IRRIGATION

Around 100 BCE, people of China used to bury clay pots filled with water called *ollas* in soil for growing plants, which is similar to '*Matka Sichai*' of desert state of Rajasthan in India and '*Pitcher Irrigation*' elsewhere. During nineteenth century in Afghanistan, unglazed clay pipes were used for growing crops. In Germany, during the year 1860, researchers started experimenting sub-surface irrigation using clay pipe to create a system which will cater both irrigation and drainage. Harris Thill of Australia developed the use of plastic to hold and distribute water in drip irrigation. Meanwhile, the researchers have tried to develop a trickle system for water delivery to plants through use of perforated pipes. The demerits of this system were that the water flow was choked due to deposition tiny particles. Simcha Blass and his son Yeshayahu of Israel in the year 1959 used plastic emitter in drip irrigation. Here the holes of the pipe were not blocked, and results were very good. Simcha Blass and Kibbutz Hatzerim created an irrigation company in 1964 named it Natafim and got patent for surface drip irrigation emitter. During 1960, the first drip tape called Dew Hose was developed by Richard Chapin of Chapin Watermatics in the United States. In the year 1987, Plasto irrigation developed T-tape in drip irrigation with slit outlet and a laminar flow track which later evolved into a turbulent flow regulating flow track. In the year 2006, Chapin Watermatics was acquired by Jain Irrigation (www.bluejayirrigation.com; www.dripworks.com; www.irrigation.learnabout.info; US Patent, 2017, Brain bridge, 2001). In India, systematic experimentation on drip irrigation was started in early seventies of 20th century by All India Coordinated Research Project on Irrigation Water Management of ICAR at MPKV, Rahuri Centre followed by TNAU, Coimbatore Centre. Later, research on drip irrigation on various crops was undertaken by other AICRP centers and state agricultural universities (SAU). In the year 1989, Jain Irrigation started commercial micro-irrigation including drip irrigation. ICAR centers and SAUs supported the research back up and Jain irrigation extended material support



Fig. 1(a). Water trickle on Shivling in Ujjain



Fig. 1(b). Water trickle on Shivling in Shyameswara temple of Bhadrak



Fig. 1(c). Water trickle on Shivling in outskrit of Bhubaneswar



Fig. 1(d). Water trickle on Shivling in Jamujhari temple in Khordha district



Fig. 1(e). Water trickle on Shivling in Faneswar Mahadev of Gurunagarsasana



Fig. 1(f). Water trickle on Shivling in Mahadev temple of Chhataber

Fig. 1(a-f) Photographs showing water dripping through traditional method of Jalavisek (controlled bathing)

for micro-irrigation spread in India including drip irrigation. The research support of ICAR and SAUs, financial support of government of India and various state governments, material and installation support of Jain irrigation and other private players, resulted in expansion of micro-irrigation in India and its spread reached to 13.78 million hectares (Anonymous, 2022).

WHY TULSI PLANT

Tulsi or holy *Basil* / sacred *Basil*, whose scientific name is *Ocimum tenuiflorum* is a sacred plant in Hindu religion. The Centre of origin of this plant is India. It is considered as Goddess *Laxmi* and without her presence, the worship of Lord *Vishnu* is incomplete. Various interesting stories are mentioned in different *Puranas* regarding the origin of this sacred plant *Tulsi*. According to one legend, during *Samudra Manthan* (Churning of cosmic ocean) by Demons and Gods, *Dhanvantari* rose from ocean with *Amrit* (the elixir of immortality). Lord *Vishnu* took it for Gods. When demons tried to steal it, *Vishnu* shed happy tears which when fell on *Amrit* gave birth to *Tulsi* (Deshpande, 2005; Wikipedia.org; Anonymous, 2019). According to another legend, *Vrinda* was the beautiful daughter of demon king *Kalanemi*. She was a great *Vishnu* devotee. *Jalandhar*, a demon king was borne out of water and became powerful after getting the blessings of Lord *Shiva*. *Jalandhar* fell in love with *Vrinda*, a pious, devoted and extremely chaste lady and married her. *Jalandhar* became very powerful due to the chastity and devotion of his wife and multiplied his strength. His arrogance multiplied further, and he thought he would be the supreme power of the universe by defeating all gods. Even Lord *Vishnu* couldn't defeat him. All gods went to Lord *Vishnu* for help. Lord *Vishnu* caught himself in dilemma, as *Vrinda* was his ardent devotee and *Jalandhar* is posing a great threat to deities. When *Jalandhar* was fighting with Lord *Shiva*, *Vrinda* was in chastity. Lord *Vishnu* knew that if *Vrinda's* chastity will not be broken, then *Jalandhara* cannot be killed. Lord *Vishnu* decided to play a trick. He went to *Vrinda* in disguising attire of *Jalandhar* while real *Jalandhar* was fighting with Lord *Shiva*. *Vrinda* couldn't recognize Lord *Vishnu* and thought he was the real *Jalandhar* and greeted

him. When she touched Lord *Vishnu*, she realized that he was not her husband *Jalandhar*. Her chastity was shattered, and her husband *Jalandhar* became vulnerable. When she realized her mistake, she asked Lord *Vishnu* to show his original form. When she saw Lord *Vishnu*, she was shattered to know that her own Lord had cheated her. She cursed Lord *Vishnu* to become a stone with anger for playing tricks to dilute her chastity. Lord *Vishnu* accepted her curse and turned into a stone known as *Shaligrama* stone which is available near Gandak river and is worshiped as Lord *Vishnu* even today in Hindu religion. *Jalandhar* was not killed as he was under protection of his wife's purity and chastity. When *Vrinda's* chastity was broken, *Jalandhar* became powerless, and he was killed by Lord *Shiva*. *Vrinda's* heart was broken down and she decided to kill herself. *Vrinda* took the head of her husband and immolated herself in the in the pyre. From the ashes, one plant emerged, and Lord *Vishnu* named it *Tulsi* and blessed the plant that she would be worshipped along with Lord *Vishnu*. She will be always in the needs of Lord *Vishnu* and without her; the worship of Lord *Vishnu* will be incomplete.

SPIRITUAL AND MEDICINAL PROPERTY OF TULSI

The significance and importance of *Tulsi* have been mentioned in various religious texts in Hinduism. Some selected verses are mentioned here. In *Skanda Purana*, it is mentioned that by worshipping *Tulsi* one can attain the same result which can be attained by worshipping *Saligrama Sila* on *Shravana dwadasi*. In *Garuda Purana* it is mentioned that by worshipping *Tulsi* then one will attain the same result which one can attain by observing fast on *Janmashtami*. *Garuda Purana* mentions that by worshipping *Tulsi* one gets the same result which one gets by bathing in *Prayaga* or leaving his body in *Varanasi* after death. There is a mention in *Agastya Samhita* that by worshipping *Tulsi* properly one fulfills the desires of the men and women in four varnas and ashramas. It is believed that in the *Kali Yuga*, if someone plants *Tulsi*, glorifies her, remembers her, irrigates her, gives her in charity, offers her to *Krishna's* lotus feet and after offering eats the remnants of the sacred leaves then all his sins are burned. As per *Narada Purana*

a person's fortune increases everyday if one begins worshipping *Tulsi* daily. In Hari Bhakti Sudhodaya, it is mentioned that that Lord *Vishnu* always stays in *Tulsi* Forest hoping that some devotee will come and offer him an unbroken *Tulsi* leaf. Narada Purana further glorifying the worship of *Tulsi* mentions that "If one chants the names of Ganga then Ganga destroys all his sins. But when someone chants the holy names of Lord Hari then *Tulsi* Devi grants him the gift of devotional service." In Garuda Purana it is mentioned that "O great Garuda, those who plant *Tulsi* Devi attains liberation for sure." *Tulsi* is considered so sacred that her single branch is equal to a hundred *pipal* trees or thousand mango trees (discoverursupersoul.com, 2023).

It is believed that the presence of *Tulsi* plant near the house brings much cheer and health to the family. Keeps the heart and mind fresh. It bestows the energy of love and devotion on devotees. Lord *Sri Krishna*, the incarnation of *Narayan* or Lord *Vishnu* is very much pleased with *Tulsi* garland or a worship by *Tulsi* leaves. No other sacred flowers or plant parts equal to this sacred leaf. It is also believed that by pouring water on *Tulsi* plant, eliminates all the sin including brahmahatya (killing of human being). Drinking water-soaked sacred *Tulsi* leaves reduces stress. Scientific studies have established that *Tulsi* plant has significant medical properties. The *Tulsi* leaves extract brings down the fever. Chewing *Tulsi* leaves along with ginger and honey gives relief from cough, cold and flu. Gargling with the *Tulsi* leaves boiled water soothes the sore throat. It is also believed that the *Tulsi* extract with honey can expel kidney stones. *Tulsi* also reduces blood cholesterol. Chewing *Tulsi* leave daily reduces the chance of mouth infections. The paste of *Tulsi* roots is used against insect bites. Drops of *Krishna Tulsi* leaf extract in eyes soothes the sour eyes. Anyway, growing *Tulsi* plant at home is very helpful be as an indoor or outdoor plant. *Tulsi* plant acts as a purifying agent in house and its surroundings. The devotees of Lord *Krishna* always prepare a garden of this sacred plant in their courtyard (www.hinduismnet.com). In Jagannath temple, Puri a special sevayat (group engaged for offering service) are assigned the duty of supplying *Tulsi* from generation to generation from

ancient times. That is reason why in *Tulsi* Puran, it is written as

"Yenmoole Sarvatheerthaani
Yenmadhye Sarvadevatha
Yadagre Sarva Vedaascha
Thulaseem-tham Namamyaham"

I bow down to the *Tulsi*, at whose base are all the holy places do exit, at whose middle all gods and goddess reside and at whose top, reside all *vedas*.

TULSI PLANT, ITS RELIGIOUS TIES AND THE ORIGIN OF DRIP IRRIGATION IN ODISHA

In Hindu religion, four salvation centers (*Mokhya dhams*) are considered as most sacred with respect to pilgrimage. Lord *Vishnu* is believed to visit these centers daily in his *pradhakhina*. When a devotee visits any one of the four centers, he or she gets the darshan of his or her Lord and achieves salvation or *mokhya*. These centers are Badrikadham in the north, Dwarakadham in the west, Jagannathdham in the east and Rameswaram dham in the south. Mythologically it is believed that Lord *Vishnu* gets up at Badrikadham and takes bath at river Alakananda, then he adorns dress or besha in Dwarakadham, he dines at Jagannath dham, Puri and sleeps at Rameswaram. That is the reason why daily *Chhapan Bhog* (56 prasad offerings) items are cooked in temple kitchen of Lord Jagannath temple and offered at Puri which is unique in the entire world. Even today the practices of *Arnaprasad* (cooked food including cereals) offered in various temples and its distribution to devotees, within and outside Odisha are in practice in almost all Jagannath temples. *Adi Shankaracharya* saw Lord *Vishnu* in these four places and hence established four maths for further spread of Hinduism (Mishra, 2011). Lord *Jagannath* is considered as one of the incarnations of Lord *Vishnu*. As Odisha was a famous site for Vaisnavas from ancient times, growing *Tulsi* plant for offering to Lord *Jagannath* was also intimately associated with Odia culture. In Odisha, each household grows at least one *Tulsi* plant in a raised earthen platform called *Tulsi Chaura* and worships it during both in the morning and evening times. In day time water and Prasad are offered, people eat a

few leaves of *Tulsi* as prasad. During evening times, Odia ladies after taking bath wearing fresh clothes, offer *Sanjabatti* (evening lamp) near the *Tulsi Chaura*. *Tulsi* plant is considered so sacred that its leaves are never plucked during night hours and during day time it is plucked only after chanting the following mantra.

“Maata Tulasi govinde hudrayanandakarini
Narayanasya pujartham chhinna masta jagat haste
Tulasi mruta namasi sadatwam keshabapriye
Keshabarthe bichhinani mama dosam na bidyate.”

O *Tulsi*! You are always in the heart of Lord *Vishnu*. I am snatching your leaves for offering to Lord *Vishnu*, please excuse me. *Tulsi* is an arable plant and cannot withstand water logging. Odisha is coming under high rainfall area having annual precipitation of 1500 mm, so people grow this sacred plant on *Chaura*, a raised platform with soil, so that there will be good drainage and it wouldn't be subjected to water stagnation. People offer water daily to this plant and eat its leaves. It's a unique system in the entire Odisha. Because it is planted in raised platform, during summer months there is water deficit to this plant due to adequate drainage because of its stiff hydraulic gradient. So, people might have thought of prolonging water release to this plant which might have led to invention of drip irrigation. Due to its special geo-location being on the coast of Bay of Bengal, its environmental temperature rises sharply from early part of March and reaches up to 44.6°C (the highest temperature attended in any individual year) by 31st March, which is also highest in the country. During this period, a part of north India remains cooler and in south India, temperature rises little higher over north India. Higher air temperature might have accelerated the evapotranspiration of water from the *Tulsi chaura*, as a result, people might have thought to provide water to *Tulsi* plant during this hot summer. When they might have poured water from the pot to the base of *Tulsi* plant at *Chaura*, water might have drained quickly, subjecting the plants to desiccation due to its strong hydraulic gradient. This situation might have forced the Odia people to think of a process or method of watering *Tulsi* plant in which water will be trickled to plant at its base for a long period during summer

season. In other words, they might have thought to develop a technique of water application where the release of water can be prolonged with a low rate of discharge so that water wastage can be reduced. This might have led to *Theki Basa* (Hanging up an earthen pot at the base of *Tulsi* plant with tine hole plugged with kusha grass) in *Tulsi chaura* starting from 1st of *Baisakh* month (14th day of the month April) i.e., *Mahabisuba Sankranti* or *Pana Sankranti* (Praharaj, 1931). In *Theki* basa earthen pot called *theke* with an earthen cover or lid is purchased from market and a small hole is made in the bottom of the pot. The hole is sealed through insertion of *Kush* grass (*Desmostachya bipinnata*) tightly, so that water will release drop by drop (Sahoo, 2014). An inverted U-shaped support is made through bamboo pieces and this *Theke* or earthen pot is hung with the help of jute *Sika* (one balance support made up off jute rope (Fig. 2)). During summer months, after morning worship of *Tulsi* plant, water is poured in this earthen pot which trickles at the base of *Tulsi* plant drop by drop. This practice is continued during summer months and removed after onset of monsoon in the beginning of the month *Asadha*. This is the first application of drip irrigation to plants in the world which dates to beginning of *Sanatan dharma* or Hindu religion (Mohanty, 1979). The method of trickling of water to *Shivalinga* from the hanged pot filled with water having a tine hole plugged with grasses is also invented in India. It is difficult to say which practice or technology earlier and which is later. Both *Halahal* (poison) and *Tulsi* plant were obtained from churning of ocean during *Satya Yug* as per mythological scriptures. But one thing is sure that trickling of water drops on *Shivalinga* drop by drop might be first step in prolong release of limited supply of water to the targeted location by reducing wastage, whereas drop by drop release of water at the base of *Tulsi* plant during the summer months by hanging pot filled with water having tine hole with grass plugging is the first experiment in drip irrigation for the plants or crops in the entire world. All other forms of primitive drip irrigation have been started much later than the former as this practice was followed from the beginning of Hindu religion.



Fig. 2(a). Worship of *Tulsi* Chaura in Sriganga

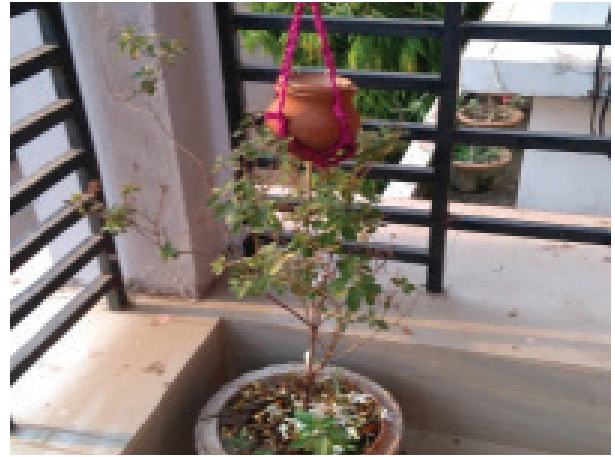


Fig. 2(b). Water trickle at the base of *Tulsi* plant in Maitrivihar



Fig. 2(c). Water trickle at the base of *Tulsi* plant in Patrapada



Fig. 2(d). Water trickle at the base of *Tulsi* plant in Bhubaneswar



Fig. 2(e). Lady devotee pouring water on mud pot to be trickled on *Tulsi* plant in Tulasipur area of Cuttack



Fig. 2(f). Shop selling holed earthen pots with hanging rope for water trickle over *Tulsi* plant at Bhubaneswar

Fig. 2(a-f) Photographs showing ancient drip irrigation technique in Odisha

CONCLUSION

Considering the above facts, it can be inferred that the first concept of water use efficiency by reducing its wastage was developed from India, which was trickling of water droplets on *Shivling* from a perforated pot with grass sealing. Similarly, the first experimentation and its application of drip irrigation to plants was made in Odisha state of India where water droplets are allowed to trickle down to *Tulsi* plant for its survival during summer months from a perforated mud pot hanged above the plant by providing artificial support. Both these religious practices are ancient to Hindu religion and are under practiced even today.

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