Technological advances for skimming fresh water in coastal rainfed areas

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The inland aquifers are suffering from the maladies of over exploitation of ground water by way of unscrupulous pumping, the coastal aquifers encounter the danger of sea water intrusion and saline water upconing. Seasonally recharged fresh water skimming is the only alternative in coastal zones to stabilize crop production.

Along the sea coast of Andhra Pradesh, there are 8.23 lakh ha of sandy soils, of which 1.74 lakh ha have shallow watertable varying from 0.3 to 3.0 m. These soils occur in narrow strip of 10 to 15 km wide and 972 km long eastern coastal strip extended from Ichapuram in Srikakulam district to Tada in Nellore district with mean rainfall of 855mm. In the coastal sands, entire precipitation percolates into the soil because of the high permeability of coastal sands and the infiltrated rain water with lesser density form fresh water lenses which floats on the sub- surface saline ground water. Most of these coastal sandy soils do not have the provision of canal irrigation facility and have only shallow depth of good quality waters. Poor recharging rate and occurrence of clay in deeper layers are the major constraints for installation of tube wells/deep wells. In most of these coastal sands, fresh water floating at a depth of 0.5 to 3.0 m below ground level and to a thickness of 3 to 4 m over saline ground waters/clay layers. The waters cannot be extracted in high quantities by conventional tube wells as they are of watertable aquifers with poor quality waters underneath. In these soils during summer months the watertable fall up to 1.8 to 3.0 m below ground level. The ground water gets recharged during the monsoon season, accumulates and by middle of November the ground water rise up to 0.3 to 0.5 m bgl in most of the areas. As irrigation supplies are not possible either though canal or tube wells in most of the coastal sandy soils, the situation has forced the farmers to search for alternatives and the technique innovated traditionally is to draw water manually that collects in the dug out conical pits locally called '*doruvus'*.

Similarly in Tamil Nadu, the coastal belt occupies about 700 km, stretching from Pulicat lake in the north to Cape Comarine in the south and 0.68 m ha is identified as coastal sandy soils. Among different types of soils, salt affected lands occupy nearly 2.04 lakh ha or 25 per cent of coastal area of Tamil Nadu. Under the situation, where ever the fresh water exist, the farmers tap them with the development of '*Oothu Kuzhi* ' (Spring) like '*doruvu'* system practiced in Andhra Pradesh.

The survey carried-out in the coastal belt of Guntur district, Andhra Pradesh., revealed that the groundwater being harvested through various structures such as traditional *doruvu* (skimming pot irrigation), traditional *doruvu* with 1 hp pumping unit, radial skimming well with horizontal collectors using 1- 5 hp pumping units, shallow tube wells with 1 hp pumping unit, two-strainer tube wells with 1/5 hp pumping unit The survey results with features of the structures are presented in Table 1.

TRADITIONAL '*DORUVU*'

Shallow depth fresh water being collected in dug out conical pits locally called 'd*oruvus'*. The seeped water is usually collected in pitchers and then splashed on vegetables flower plants, groundnut and nurseries of paddy, vegetables tobacco and casuarina etc. The water collected from a d*oruvu, that* occupies an area of about 200 sq.m is just sufficient for irrigating an area of 800 sq.m . Maintenance of 10-12 such d*oruvus* is a common practice for each hectare of land. The disadvantages of traditional d*oruvus* include:

- Wastage of productive land towards d*oruvus*, which is about 20% of the land covered under irrigation.

- Unproductive evaporative loss of fresh water from open water surface of d*oruvus*.

- Irrigation process involving manual splash watering requires huge application expenditure and does not permit the use of modern irrigation equipment.

- More chances of proliferation of vector borne diseases like mosquito breeding in open pits.

Radial skimming well (improved *doruvu* technology)

To overcome these constraints, the skimming well technology has been evolved by the All India Coordinated Research Project on Management of Salt affected Soils and Use of Saline Water in Agriculture, Bapatla Centre of Acharya N. G. Ranga Agricultural University, popularly known as 'Improved *Doruvu* Technology' to skim the shallow depth fresh water in coastal aquifer without disturbing the hydro-dynamic conditions. The system consists of a collector well with lateral collector lines installed at shallow depth. The collector lines are connected to the sump on either side and imbedded for the collection of lateral flow by digging a trench. Depending on the watertable head above the collector pipes, the collectors are continuously charged with subsurface fresh waters throughout their length and water flow into the well under gravity. The recharge occurs due to precipitation, upstream canal seepage and also by recycling of irrigation water. As a result of this recharge, flow lines are sustained. The advantages of skimming well over the traditional d*oruvus* is as follow.

- Over exploitation of ground water beyond the collector line depth is not possible, and it serves as control of saline ground water upconing problem (or) against sea water intrusion as commonly observed in *lanka* lands.

- The land wastage and water evaporation is avoided and can be used for productive purposes.

- This technology effectively facilitates the adoption of modern irrigation systems like drips and sprinklers and helps in improving upon the water use efficiency.

If properly planned and installed, the systems can be used to create irrigation source as well as to control watertable in the cultivable areas in the periods of submergence. With this system, sufficient water expected to be made available to *rabi* and plantation crops and effective usage of water through sprinkler and drip irrigation methods possible. The system also replaces the existing traditional 'd*oruvus'*.

Installation of skimming well

To decide upon the suitability of the site for installing skimming well, a detailed survey of the project site w.r.t. water-table depth and quality, soil texture and structure, land topography, number of existing traditional d*oruvus,* existing and ensuing cropping pattern is undertaken. In general, the sandy soils with watertable depth remaining with in 1.8 to 2.4 m are most suitable. Once the site is selected, the installation is done during May to June i.e prior to commencement of monsoon season when, watertable is usually at deepest level. The installation process begin with digging of trench of 35-40 m length on either side of the sump well, with top width 5-7 m and bottom width 3m, either manually or through poclainer machines down to a depth of watertable. After digging the trench, a sump well is constructed with RCC rings (1.5 m dia. and 0.3 m height) to a depth of 4.8 m from the ground surface such that the well depth is 2m below the critical watertable.

Following the installation of sump well, the installation of collector lines starts with lying-in and the connecting the stone-ware pipes in the trench below the watertable depth. The dimensions of stone ware pipe are; ID 0.10 - 0.15 m length 0.6 m having 18-21 perforations(5mm dia.) arranged in 3 rows spaced 8 cm apart. Holes of 0.18 m dia are drilled on either side of the sump well ring imbedded to a depth of collector line installation to connect the stone-ware pipe collector line. After connecting stone ware pipe with sump well, other pieces of stone-ware pipe are interconnected to each other to form a collector line. The perforated portions are laid downside and a slope of 0.2% is maintained to facilitate free flow of water towards the sump well. Since the collectors are installed in the presence of shallow ground water, iron gudders are used to avoid slipping of sand. Baby chips (8-12mm size) are placed all around the collector line (thickness 5 cm) to serve as a filter material. The stone-ware pipe pieces are interconnected using cleaned coconut coir. As precautionary measure, the top of collector line is covered with a 30 cm wide strip of polyethylene sheet before refilling of trench to avoid entry of fine clay and sand material from top portion of the soil column. In recent times, the collector lines are being installed using Corrugated PVC pipe and nylon mesh envelop.

Precautions during installation of skimming well

- While constructing the sump well, RCC rings should be selected as per specific standard so as to avoid their breakage during installation and for their longer durability.

- Remove the temporary plugging at the end of the collector line that opens into sump. However, keep its other end plugged, otherwise sand may enter and cause hindrances to the free flow of water.

- The perforated portion of each stone ware pipe should face the ground during installation of collector line.

- Frequent pumping of water during installation will maintain the water level below the placement level of collector line and also facilitate the removal of sand that might have accidentally entered the collector line.

- Frequent pumping should be continued even after installation to avoid clogging of collector line.

Adaptability of skimming well technology

With built-in advantages of skimming well, the technology has become very popular with the farmers of coastal sandy belt in and around Bapatla area. With the developed technology more than 84 skimming wells covering 160 ha cultivable area being installed in 22 villages of Guntur and Prakasam districts of Andhra Pradesh. Five skimming wells with horizontal collectors were exclusively installed in Guntur district for drinking water supply with the help of NGO's and Rural drinking water scheme, Govt. of Andhra Pradesh. Similarly Tamil Nadu Agricultural University introduced the skimming technology in Myladuthrai and Nagapatnam districts by installing two skimming wells after detailed investigations on a pilot scale.

On the whole, experiences show that system is able to supply good quality water that is sufficient to meet crop demands of 2-3 hectares area during rabi through the use of sprinklers or of 4-5 hectares of plantation crops through mini sprinkler irrigation system.

Sprinkler system of 8-10 sprinklers can command an area of 2 hectare for cultivation of following crops and for raising nurseries.

Kharif - Rice, Tobacco, chilli, casuarina, mango and coconut nurseries.
- Crussandra and Crysanthumum.

Rabi - Groundnut, Green gram, Black gram Chilli, Brinjal, Bhindi and Colcacia
- Marigold and Crussandra

Summer - Paddy nursery

Similarly with Drip/Micro-sprinkler system can be operated for cultivation of plantation crops in 4-5 hectare area.

Plantation crops - Mango, Sapota, Guava and Watermelon as inter crop.

Hydraulic performance of skimming wells

Measurements on the area of influence of wells installed at Reddypalem showed that the collector line with 6" dia. receive water from a surrounding of 50 m radius on either side of the sump well and a spacing of 100m between two well collectors is to be maintained. The bi-directional water discharge rate into sump depended upon the hydraulic head over the collector line and soil hydraulic conductivity(Table 2). The hydraulic conductivity value estimated for sandy soils of Reddypalem dominated with coarse sand is 20.04 m/day and for sandy soil dominated with fine sand is 7.06 m/day.

Table 2: Collector discharges at different hydraulic heads in coarse and fine textured soils at Timmareddypalem

S.No	Hydraulic Head(m)	Discharge in Litres per second	
		Sandy soil dominated with coarse sand	Sandy soil dominated with fine sand
1.	0.4	4.86	2.71
2.	0.6	7.34	4.09
3.	0.8	9.86	5.50
4.	1.0	12.42	6.90
5.	1.2	15.01	8.91

The major factors that influence design criteria are: a) Installation depth to avoid entry of underground saline water; b) Collector line spacing as a function of their length and soil hydraulic conductivity.

SHALLOW TUBE WELLS AND MULTI-STRAINER TUBE WELLS

During the recent past, innovative and progressive farmers tried to install shallow depth (4.5 - 6.0m deep) low discharge tube wells and multi-strainer bore wells with varying designs in Andhra Pradesh and Tamil Nadu to tap the top layered shallow depth fresh water. These systems performance is assessed by AICRP Saline Water Scheme, Bapatla in terms of yield, quality, underground quality changes using state of art multi-electrode imaging techniques and economic viability and social acceptability survey.

Performance of different skimming structures

- Harvested water quality analysis was carried under different skimming structures. There was little change in the salinity of water harvested through the traditional *doruvus* with pot irrigation (0-1.5 %), traditional *doruvu* with 1 hp pumping unit (1.5 – 5.9 %), skimming well with horizontal collectors (1.5 – 5.6 %). In case of shallow tube well, a gradual increase (8.1- 46.0 %) in salinity of pumped waters with pumping time was observed. In case of multi-strainer well a moderate rise of salinity (3.5 to 13.7 %) was observed.
- Multi-electrode imaging studies carried-out under horizontal skimming well and shallow vertical tube well with pumping revealed that there is abnormal resistivity reduction in vertical tube well area. The reduction in resistivity indicates the degrading of water quality and there is a possible upconing of saline waters. In case of horizontal skimming well area negligible change in resistivity, which proves that there is no upconing and horizontal skimming is safe method of harvesting ground water.
- The economic appraisal of the improved technologies at farmers level – using discounting techniques revealed that skimming well with horizontal collectors contributes higher benefit cost ratio(2.15) to the farmers followed by multi-strainer tube well(1.96) and shallow tube well(1.35) technologies.

CONCLUSION

The shallow fresh water floating over the saline water is the life line of the coastal region and any overexploitation of this resource may lead to the disastrous consequence viz., saline aquifer. To avoid this situation the withdrawals from the aquifer should be commensurate with its seasonal recharge.

From the point of view of preventing salt water intrusion into the inland fresh water aquifer and in order to keep the saline fresh water interface into coastal aquifers far below the critical levels, the skimming well with horizontal collector system be a viable solution. Also this system serves the purpose of harvesting fresh water or relatively fresh water for stabilizing crop production in a profitable way in the coastal belts.

Though the skimming well technology has been accepted and adopted by few farmers of coastal sandy soils of Andhra Pradesh, its further adoption by the small and marginal farmers is constrained due to non availability of funds for installation of the these wells, purchase of oil engine/electric motor and sprinkler/drip systems. If the subsidies for installation are provided by the Government of India, the technology can be adopted not only in Andhra Pradesh, but also in coastal parts of Tamilnadu, Orissa and West Bengal states.

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Table 1 : Classification of different Skimming Structures adopted by the farmers of the Bapatla coastal belt and their features

S. No.	Parameters	Traditional *doruvu* (pot irrigation)	Traditional *doruvus* with 1 hp pumping unit	Skimming well with horizontal collectors	Open tube well with 2" suction pipe and 1 hp pumping unit	Two strainer bore well with 1 hp pump unit
1	Period of practice	70-75 years old system	8 years	12-15 years	3-4 years	2-3 yrs
2	Depth	1.8-3.6 m	1.8-3.6 m	2.4-4.8 m	5.7-6.3 m	5.1-6.0 m
3	Summer water column	0.6-1.2 m	0.6 - 1.2 m	0.9-1.8 m	2.4 - 3.3 m	2.4 - 3.3 m
4	Ave. no. of units per ha. to cover ID crop needs	8 (0.3-0.4 acre each)	5 *doruvus* + 1 pump (Shift type pump unit from one to other *doruvu*)	1 (Serves upto 1-2 ha.) Fixed/Portable pump unit	5 wells + 1 pump (Shift type pump unit)	3 wells + 1 pump (Shift type pump unit)
5	No. of persons required/hectare	8	2	1	2	2
6	Crops grown	Chilies, Paddy nursery , vegetables and flowers.	Chilli, groundnut , tobacco/paddy nurseries, flowers and vegetables.	Chilli, groundnut vegetables, paddy nursery and plantation crops .	Chilli, groundnut, vegetables and nurseries.	Chilli, groundnut and flower gardens.
7	Farmers adaptability	Common traditional system	Widely converting from pot watering to pumping unit by all marginal farmers	Mostly commercial/ progressive farmers adopted as a permanent source of irrigation.	Very recent development to irrigate groundnut crop	Very recent development to irrigate groundnut crop
8	Appox. no. of systems in Guntur district	25000	850	74	250	260
9	Expected life	3-4 years	3-4 years	20 years	3-5 years	3-5 years
10	Appox. cost of system per ha	Rs.3200/- (8 *doruvus*)	Rs. 16000/- (5*doruvus* + 1 Pump unit)	Rs. 50 000/- (1 structure + 1 Pump unit)	Rs. 22500/- (5 structure + 1 pump unit)	Rs. 23700/- (3 structures + 1 pump unit)