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# DRAINAGE OF IRRIGATED LANDS

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**ABSTRACT** Salinity affects millions of hectares of once productive land in many countries. Besides economic losses, rapid salinization of land and water resources is inflicting environmental damage, particularly in irrigated areas where salinity increase has charted a parallel path with irrigation development. However, irrigated land use as such is not responsible for salinization, but it is the faulty irrigation practices, inadequate provision of drainage and lopsided economic incentives that play a major role. Different measures including surface, subsurface and bio-drainage systems have been adopted to prevent/mitigate and reclaim the affected areas. Large scale adoption of mechanized subsurface drainage (SSD) systems is at its inception stage. Experiences from large scale SSD installations in the northern states of Haryana, Rajasthan and Maharashtra have evidenced that the technology can be successfully adopted in reclaiming saline and waterlogged lands while surface drainage and bio-drainage have limitations and do not show improvement in soil and crop productivity. Two large scale SSD projects were installed on 2165 ha at Dudhgaon and Kasabe Digraj in Sangli district of Maharashtra (India) in the year 2005 to 2008. There is good improvement in the soil properties of affected lands within one year due to SSD installation in the fields. The pH decreased from 8.11 to 7.63, the soil conductivity EC from 8.11 to 4.60 dS/m, SAR from 7.10 to 3.94 and ESP from 9.31 to 4.60; which shows improvement in salt affected soils. Yield of sugarcane increased from 75 T/ha to 172 T/ha within a period of one year.

**Keywords:** Productive land, Faulty Irrigation, Water logging, Salinization, Subsurface Drainage (SSD), Reclamation.

**INTRODUCTION** Soil and water are the two most important resources required for the living things on the earth, in general and mankind in particular. In India, the importance of the above two vital sources are still more critical, since, this nation has to support 16 percent of the world's population with 2.3 percent of land resources and 4.0 percent of water resources available. Lately, the quality and quantity of the two are slowly, but steadily being deteriorated and reduced.

Land degradation is the major problem of Indian agriculture. Most of the land area in our country shows evidence of degradation, affecting thereby the productive resource base. Out of the total cultivated area of 141 Mha, 30.54 Mha are considered as affected in

which, salt affected soil is about 8.56 Mha. with about 5.6 Mha occurring in irrigation commands. Five states, namely, Haryana, Punjab, Rajasthan, Gujarat and Andhra Pradesh accounts for 48 percent of total salt affected soils of the country. Maharashtra state has salt affected area to the extent 0.6 million hectares

The twin problems of water logging and soil salinity are of great concern since the introduction of irrigated agriculture in semi-arid and arid regions. The land degradation due to these problems was first noticed in India in the last century. The investigations into the problem resulted in a recommendation that drainage should be planned for all the irrigation systems to derive long term benefits from the investment on canal irrigation. However, much progress has not been made in this direction. Due to the alarming rise of the problem area in the irrigation commands that developed after independence, the need for research and implementation of drainage measures has found emphasis in various forums.

There are continuous reports of degradation of lands due to water logging and soil salinity from almost all irrigation projects. Introduction of irrigation in semi-arid and arid areas, where surface and underground drainage is poor, results in a rise of the water table. After the introduction of irrigation in many canal commands the rise of water table is resulting in substantial areas going out of cultivation due to water logging. Such a situation is detrimental to crop growth as the land is rendered either uncultivable or loses productivity. In many canal commands the water table has a rising trend (Singh, 1993)In view of the above, the present investigation aimed to study the effect of drainage systems for improvement of salt affected water logged soils in western Maharashtra.

**Need of Drainage** In India 164 districts suffer from the problem of one or more type of soil salinity. The problem occurs in varying degree in the states of West Bengal, Orrissa, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Maharashtra and Gujrat. The important areas needing attention are the sundarban of West Bengal, the delta areas of Krishna, Godavari, and Kaveri, Kari soils in Kerala, Khar land of Maharashtra and costal areas of Gujrat and Rann of Kutch. Coastal saline soils are found along the long coastal line which runs about 6000 Kms. (Table 1). The nature of the problem is different in different parts and so the problems associated with these lands also vary.

In the canal irrigated are as ,the mis-use and abuse of waters has resulted in the development of the twin problems of waterlogging and soil salinization. It is estimated that nearly 5.5 million ha are also water logged (Table 2). Appropriate drainage can overcome the waterlogging and salinity problems. Subsurface drainage is an effective tool of combat this twin problem water logging and salinity and thus to protect capital investment in the irrigated agriculture and increase its sustainability. In India however, subsurface drainage has not been implemented on a large scale, in spite of numerous research activities that proved its potential.

**Table 1:** Category and extent of salt affected soils.

| Soil category | States | No. of districts affected | Area affected ('000 ha) | Rainfall range (mm) |
|---|---|---|---|---|
| Alkali soils of Indo-gangetic alluvial plain | Punjab, Haryana, Uttar Pradesh, Bihar, Rajasthan | 30 | 2400 | 600-1000 |
| Saline soils of Indo-gangetic alluvial plain | - do - | 23 | 615 | 350-650 |
| Inland saline soils of arid region | Rajasthan, Gujarat. | 17 | 455 | 150-500 |
| Salt affected soil of Vertisols (black soil) Region | Gujarat, Madhya Pradesh, Maharashtra, Tamil Nadu, Karnataka, Andhra Pradesh, Rajasthan (Mixed red and black) | 51 | 2352 | 540-1040 |
| Coastal salt affected soils | | | | |
| a) Saline soils of sub humid to humid and deltaic regions | West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Karnataka, Goa, Maharashtra, Gujarat | 30 | 1654 | 830-2500 |
| Deltaic regions | Karnataka Goa, Maharashtra ,Gujrat | | | |
| b) Saline soils of arid | North Gujarat, Rajasthan | 7 | 700 | 300-500 |
| c) Acid sulphate and saline soils of humid tropics. | Kerala, West Bengal, Andaman and Nicobar Island | 6 | 250 | 200-3000 |

**SUBSURFACE DRAINAGE IN IRRIGATED COMMAND AREAS-CASE STUDIES** Studies on subsurface drainage were initiated at CSSRI as early as in 1972 but a major thrust could be made in 1980 once a project site was taken on lease from village Panchayat Sampla. Since then there was no looking back and major initiatives were taken to perfect the technology with international and national corporation Since the sites are will spread over different agro-climatic conditions, this experience culminated in the development of guidelines on drainage design and evaluation.

**Sampla** During the year 1979 , a part of the land of the Village Panchayat Sampla was taken on lease to conduct experiments on reclamation of Waterlogged saline lands. In the first small scale experiment, open and pipe drains were established with a spacing of 25 m for open and 50 m for pipe drainage (design spacing). The successful operation of the

**Table 2**: Estimated waterlogged areas in different states.

| State | Area (Lakh ha) |
|---|---|
| West Bengal | 18.5 |
| Punjab | 10.9 |
| Uttar Pradesh | 8,1 |
| Haryana | 6.2 |
| Gujarat | 4.8 |
| Rajasthan | 3.5 |
| Andhra Pradesh | 3.4 |
| Maharashtra | 1.1 |
| Kerala | 0.6 |
| Orissa | 0.6 |
| Madhya Pradesh | 0.6 |
| Tamil Naduy | 0.2 |
| Karnataka | 0.1 |

two systems in reclaiming saline soils encouraged to take up this technology in a more theoretically sound manner and covering a relatively larger area to test various depths and spacing and to assess the performance of different drainage materials (Rao eral,1986). The land under reclamation got reclaimed right in the first year following leaching by rainfall and irrigation water applied before the sowing of the first crop. The good yields of different crop such as cotton, wheat, and barley could be taken even in the first year of cropping . The maximum yield was obtained in plots with drain spacing of 25 m and minimum in the plots with 75 m spacing. However, the difference in yield got blurred over the years such that within three years, yield even in plots with 75 m spacing was as good as that of the normal lands. During this period, pearl millet and mustard crops were also grown with good yields. Salinity of the soil after 10 years of cropping and average yield of wheat in the plots with different drain spacing revealed that the land reclamation programme is sustainable. The drainage systems were handed over to village Panchayat during the year 2000. Our experience of handing over the system to village Panchayat was not good in the sense that the system was not pumped from then onwards.

**Gohana/Kalayat** Harayana Operational Pilot Project, Haryana came into existence in 1995 with funding support from the Government of the Netheriands. Development of Agriculture , Haryana was the nodal agency to execute the work and the institutional support was extended by the Central Soil salinity Research Institute, Karnal and the CCS Haryana Agricultural University, Hisar for the Gohana and Kalayat Projects respectively. A total of 2300 ha was covered under subsurface drainage at the two sites. The results revealed that water table remained deeper in drained than un-drained (Sharma and Gupta, 2006) snd wheat crop yields improved after the land was treated with subsurface drainage in 1997-98. Following the closure and handling over of the project to the Farmers Drainage Societies (FDSs), a survey was conducted by the Department of Agriculture, the implementing agency, to estimate the net benefits to the farming community for the year 2002-03 for the Gohana site. As per this assessment, total benefits for the 23 blocks under subsurface drainage were Rs. 5.3 million over the un-drained control. Clearly, the

benefits per year are to the tune of 10% of the present day total cost to cover 1200 ha area under subsurface drainage estimated at 4.8 million (HOPP,2004)

**Tungabhadra command in Karnataka** A number of subsurface drainage pilots were laid out in this command by the state CADA with funding from the Ministry of Water Resources, Govt. of India. The salt balance studies in one of the projects covering an area of 62 ha revealed a net outgo of salts from the root zone as a result of subsurface drainage with 340 tonnes of salts (Manjunatha et al, 2004) removed compared to 240 tonnes of salts applied during August 1998 to May 2000. Thereafter, the salts removal reduced considerably due to the blockage of the system at few places by the farmers to save water and prevent losses of valuable soil nutrients. It could also be attributed to lower salinity of the drainage water as a result of land reclamation. As a consequence, an increase in soil salinity was observed during December 2001 to April 2002. This information could be used to convince the farmers to clear the blockage of the drainage system as well as to create awareness for a properly maintained and operated drainage system to reclaim the salt affected soils.

It would suffice to say that evidence are now available that with appropriate subsurface drainage yield could be increased by 20 to 340% (Table 3) and maintained at the higher level.

Cropping intensity could be increased to 200% in areas where nothing grew before (Table 4) and cropping patterns changed from subsistence type to more profitable ones. To keep the land under cultivation is the key word to the sustainability of a land reclamation programme.

**SUBSURFACE DRAINAGE IN NON-COMMANDED AREAS-CASE STUDIES** It is commonly believed that problems of water logging and soil salinization infest the commands of the major projects. Contrarily, if the situation is same, even the water brought into the command through minor irrigation works would result in rising water table and soil salinization would be a foregone conclusion. A large area of the black cotton soils in Maharashtra has been affected by the twin problems in lift irrigation commands operated by the farmers. Most recently, a private entrepreneur has joined hands with the state department and initiated subsurface drainage activities in the lift irrigation commands of Maharashtra as a forward integration to his on-going activities of manufacturing irrigation and drainage pipes. The entrepreneur has already completed a project while another is in progress (Table 5). A project is just to begin for Belgaum district in Karnataka.

The most important feature of this project is that the investments on these projects is shared by the Central Government, State Government and the beneficiary in ratio of 60:20:20. Banks have come forward to extend the loan facility to the beneficiaries.

**Table 3:** Impact of land reclamation on crop yield

| Place | Crop | Crop production (t/ha) | | |
|---|---|---|---|---|
| | | Before drainage | After drainage | Increase over pre-drainage (%) |
| Sample (Haryana) | Wheat; | 0.0 | 2.5-4.9 | - |
| | Barley | 0.0 | 2.1-4.2 | - |
| Ismaila (Sampla) | Wheat | 0.9 | 1.9 | 111 |
| Konanki (A.P.) | Paddy | 3.7 | 5.6 | 51 |
| Uppugunduru (A.P.) | Paddy | 3.6 | 5.2 | 45 |
| Segwa(Gugarat) | Sugar cane | 78-104 | 105-140 | 35 |
| Islampur (Karnataka) | Cotton<br>Paddy<br>Sunflower<br>Sorghum<br>Wheat | 3.3<br>1.4<br>3.0<br>6.8<br>4.0 | 10.4<br>5.5-6.2<br>7.4<br>11.6<br>6.7 | 215<br>290-340<br>146<br>70<br>68 |
| Gohana | Wheat<br>Paddy<br>Pearl millet | 3.1<br>1.4<br>0.9 | 3.6<br>1.7<br>1.2 | 18<br>21<br>40 |
| Vaddarathi | Rice | 3.5 | 8.4 | 140 |
| Gundur | Rice | 2.8 | 8.1 | 189 |
| Siddapur | Rice | 2.4 | 7.3 | 204 |
| Gangavathi | Rice | 4.0 | 7.9 | 98 |
| Sindhanur | Rice | 2.2 | 3.7,6.7-7.5 | 223 |
| Gorebal | Rice | 2.3 | 7.2 | 213 |
| Mouje Digraj | Sugarcane | 7.5 | 172 | 129 |

**Table 4:** Cropping intensity as influenced by land reclamation

| AREA | BEFORE DRAINAGE | AFTER DRAINAGE | % INCREASE OVER PRE-DRAINAGE |
|---|---|---|---|
| SAMPLA | 0 | 200 | - |
| ISMAILA(SAMPLA) | 73 | 148 | 103 |
| KONANAKI | 70 | 90 | 29 |
| UPPUGUNDURU | 130 | 165 | 27 |
| ISLAMPUR ORP<br>PHASE II | 0<br>88 | 27,35,200 * *<br>144,156 * | -<br>77 |
| GOHANA | 117 | 175 | 50 |

** In first second and third year

* In first and second year

**Table 5:** Subsurface drainage activities in Maharashtra under lift irrigation schemes

| PROJECT | PROJECT RELATED INFORMATION | |
|---|---|---|
| RECLAIM – I DUDHGAON PROJECT (SANGLI | TOTAL PROJECT COST MAIN DRAIN | RS.446.51 LAKH (INCLUDING |
| | TOTAL AREA | 1100 HA |
| | NO OF BENEFICIARIES | 1326 |
| | OUTLET | GRAVITY |
| | MAIN DRAIN | OPEN |
| | COLLECTORS | 80-455 MM DIAMETER PIPES |
| | LATERALSL | 80 MM PERFORATED PIPES |
| RECLAIM-II KASABE DIGRAJ PROJECT (SANGLI) | TOTAL PROJECT COST MAIN DRAIN) | RS.553.33 LAKH (INCLUDING |
| | TOTAL AREA | 1065 HA |
| | NO OF BENEFICIARIES | 1159 |
| | OUTLET | GRAVITY |
| | MAIN DRAIN | OPEN |
| | COLLECTORS | 80-250 MM DIAMETER PIPES |
| | LATERALS PIPES | 80 MM DIAMETER PERFORATED |

**Drained versus Un-Drained** Besides the positive effects of drainage, a look at the data from un-drained areas also makes an interesting reading. It could be seen that un-drained plots continued to remain saline and barren while optimum yields could be obtained in the treated plots at Sampla . More than 1/3 rd of salts present in the soil profile leached down in treated area at Gohana .

**SUBSURFACE DRAINAGE PROJECTS IN MAHARASHTRA**. Soils of the Maharashtra are black soils, commonly known as black cotton soil belonging to vertisol group; which are low in drainability with low hydraulic conductivity. Soil pH was in the range of 8.13 to 8.52, EC 2.22 to 17.82 (dS/m), ESP 7.04 to 17.50 and hydraulic conductivity 0.0236 to 0.0579 m/day. Water table fluctuations were in the range of 0.265 to 1.85 m from the surface in different seasons. Perforated corrugated flexible PE Pipes of 80 mm diameter with envelope were used for laterals , and flexible PE Pipes of 80 to 455 mm diameter were used for collector drains. The collector drains outfall into an open main drains. The depth of laterals vary from 1.0 to 1.5 m and lateral drain spacing ranges from 20 to 30 m. Inspection chambers were fitted as per field requirements. Other drainage work like open drains and bio-drainage was done by agencies like State Forestry and Agriculture department in this area on a small scale.

## IMPACT OF SUBSURFACE DRAINAGE

**Soil Improvement** Perodical analysis of soil samples from subsurface drainage installed area is given in Table 6 to 9 . The soil samples from six locations were collected at the depth of 0-30 cm for three years. Irrigation was applied at 15 to 20 days with rainfall.

**Table 6:** Periodical analysis of salt affected soil after installation of SSD.

| Month | pHe | | |
|---|---|---|---|
| | **2005** | **2006** | **2007** |
| January | 8.06 | 7.93 | 7.86 |
| February | 8.47 | 7.88 | 7.70 |
| March | 8.38 | 7.63 | 7.60 |
| April | 8.27 | 7.77 | 7.77 |
| May | 7.99 | 7.28 | 7.81 |
| June | 8.05 | 7.41 | 7.55 |
| July | 8.27 | 7.51 | 7.65 |
| August | 7.96 | 7.53 | 7.50 |
| September | 7.96 | 7.69 | 7.55 |
| October | 7.97 | 7.32 | 7.65 |
| November | 7.90 | 7.60 | 7.40 |
| December | 8.00 | 7.55 | 7.50 |
| **Mean** | **8.11** | **7.59** | **7.63** |

**Table 7:** Periodical analysis of salt affected soil after installation of SSD

| Month | ECe (dS/m) | | |
|---|---|---|---|
| | **2005** | **2006** | **2007** |
| January | 8.06 | 7.86 | 6.77 |
| February | 8.47 | 7.25 | 5.09 |
| March | 8.38 | 7.56 | 7.18 |
| April | 8.27 | 7.55 | 6.68 |
| May | 7.99 | 7.26 | 7.27 |
| June | 8.05 | 5.00 | 5.11 |
| July | 8.27 | 4.85 | 4.07 |
| August | 7.96 | 3.74 | 2.45 |
| September | 7.96 | 2.95 | 2.65 |
| October | 7.97 | 5.23 | 2.75 |
| November | 7.90 | 5.21 | 3.00 |
| December | 8.00 | 4.60 | 3.15 |
| **Mean** | **8.11** | **5.75** | **4.60** |

There was decrease in pH within three years from 8.11 to 7.63, EC 8.11 to 4.60 (dS/m),SAR 7.10 to 3.94 and ESP 9.31 to 4.60, indicating reduction in salt content due to subsurface drainage.

**Table 8:** Periodical analysis of salt affected soil after installation of SSD.

| Month | SAR | | |
|---|---|---|---|
| | **2005** | **2006** | **2007** |
| January | 7.54 | 6.15 | 3.99 |
| February | 7.89 | 6.57 | 4.10 |
| March | 8.39 | 4.77 | 4.83 |
| April | 8.60 | 5.62 | 5.23 |
| May | 9.12 | 4.68 | 4.72 |
| June | 8.60 | 1.87 | 4.08 |
| July | 6.77 | 2.65 | 3.34 |
| August | 5.04 | 3.38 | 3.10 |
| September | 5.20 | 2.89 | 2.47 |
| October | 5.23 | 3.69 | 3.16 |
| November | 6.29 | 2.52 | 3.71 |
| December | 6.57 | 2081 | 4.58 |
| **Mean** | **7.10** | **4.05** | **3.94** |

**Table 9:** Periodical analysis of salt affected soil after installation of SSD.

| Month | ESP | | |
|---|---|---|---|
| | **2005** | **2006** | **2007** |
| January | 9.96 | 7.89 | 4.67 |
| February | 10.49 | 8.51 | 4.84 |
| March | 11.23 | 5.863 | 5.92 |
| April | 11.54 | 7.10 | 6.52 |
| May | 12.32 | 5.70 | 5.77 |
| June | 11.53 | 1.51 | 4.81 |
| July | 8.81 | 2.67 | 3.71 |
| August | 6.24 | 3.76 | 3.35 |
| September | 6.48 | 4.52 | 2.41 |
| October | 6.52 | 4.22 | .43 |
| November | 8.09 | 2.48 | 4.26 |
| December | 8.51 | 2.91 | 5.55 |
| **Mean** | **9.31** | **4.76** | **4.60** |

**Table 10:** Yield of sugarcane in saline-sodic soil after SSD.

| Year | Crops grown | Cost of cultivation Rs./ha | Yield t/ha | Net Returns Rs./ha | Profit Rs./ha |
|---|---|---|---|---|---|
| 2003-04 | Green manuring dhaincha | 7900/- | 15 | -- | -- |
| 2004-05 | Sugarcane planting | -- | -- | -- | -- |
| 2005-06 | Sugarcane | 62,500/- | 87 | 121,800/- | 59,300 |
| 2006-07 | Sugarcane ratoon | 37,500/- | 82 | 114,800/- | 77,300/- |
| | Sugarcane seed production | 70,500/- | 167 | 233,800/- | 163,300/- |
| | Total | -- | -- | 470,400/- | 299,900/- |
| 2004 | Cost of subsurface drainage/ha | 56,207/- | -- | -- | -- |

**B: C ratio: 2.586**

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