International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No. (02), January 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

IMPACT OF SUB SURFACE DRAINAGE ON SOIL SALINITY RECLAIMATION IN CHAMBAL COMMAND AREA, KOTA, RAJASTHAN

Smriti Mathur[1] , Mueena Samar[2]

[1]Research Scholar, Career Point University, Kota, Rajasthan (India)

[2] Assistant Professor Department of Engineering Chemistry,

Vedant College of Engineering and Technology, Bundi, Rajasthan (India)

ABSTRACT

The Chambal Command Area (CCA) comprises of an area of 385,000 ha, of which 229,000 ha have been irrigated since 1960. Annual rainfall in the CCA ranges from 600 to 1400 mm, with an average of 740 mm. Approximately 85% rainfall occurs during the main monsoon season from July to September. Intensive irrigation takes place from October to April. Water logging and soil salinity problems in the CCA have continued to increase since irrigation was first initiated. The causes of water logging and salinity include canal seepage, excess water from on-farm irrigation practices, and lack of effective internal drainage characteristics of the soils. By 1990, about 20,000 ha of the irrigated lands are found saline.

One of the test sites where soil salinity reclamation was planned by RAJAD Rajasthan Agriculture Drainage Research Project, CAD Kota in collaboration with Canadian International Development Project in 1991 is the Hastinapur Test site. This paper summarizes the methodology to evaluate the impact of subsurface water on soil salinity reclamation at this test site. The main objectives of the proposed research work is to collect and evaluate soil samples of highly saline subsurface drainage plot and control plot from the test site which were installed in 1993 by RAJAD and monitored for subsequent years up to 1998. The long term impact of subsurface drainage on soil salinity is measured using standard chemical tests. This research is conducted to assess the chemical, physical and biological soil conditions, the effects of drainage on crop production and the relation with farm operation and irrigation practices.

Key words: Irrigation practices; Subsurface; Drainage; Water logging; salinity reclamation.

I. INTRODUCTION

Irrigation development is largely responsible for making India self sufficient in food grains production but the negative aspect is drainage has not been given importance as much as irrigation. Adoption of Sub surface drainage technology is probably one of the best ways to increase resource use efficiency in order to increase crop production and sustain natural resources like soil and water in severely water logged saline soils (Babu et

IJARSE
ISSN: 2319-8354

al., 2008). So there is a great demand for the research and developmental efforts to reclaim all the salt affected and water logged soils by providing drainage and bring them back to non saline productive soils.

Soil, land and water are essential resources for the sustained quality of human life and foundation of agricultural development (Babu et al., 2008). In the case of India, agriculture is a backbone of its economy in food production and employment point of view. It contributes about 17% of the Gross Domestic Product (GDP) and employing around 60% of its adult population (Chahar and Vadodaria, 2008). Efficient management of land and water resources is a major challenge for the scientist, planners, administrators and farmers to ensure food, water and environmental security for the present and future generations. After green revolution major emphasis was given on four elements of agriculture namely, improved quality seeds, fertilizers, pesticides and irrigation. The role of irrigation can be judged from the fact that, except in rare and limited areas, there has been no green revolution in India on un-irrigated land. As a result area under major and minor irrigation increased from 9.70 million ha during pre-plan to 42.77 million ha at the end of ninth plan. Area under minor irrigation also increased from 12.90 million ha in pre-plan period to 67.32 million ha at the end of annual plan 2000-01(Chahar and Vadodaria, 2008). Due to excess irrigation most of the area under irrigation is affected by the problem of soil salinity; and it became a major limiting factor for agricultural crop production (Kapourechal et al., 2013).

Soil salinization process can be either natural or may be imposed by human activities. The latter usually arises from irrigation in areas with low rainfall and high evaporation. In such conditions, the necessary steps are conducting leaching practices and/or performing a desirable drainage system (Kapourechal et al., 2013). It is estimated that up to 20 % of irrigated land in the world is affected by different levels of salinity and sodium content (Fard et al., 2007). Drainage maintains the productive capacity of soil by removing excess water, improving the soil moisture, improving the air circulation and reducing salt content and erosion (Chahar and Vadodaria, 2008). Soil salinity is also a major environmental and agriculture issue in Rajasthan. According to Soil Salinity Research Institute about 1,77,093 ha of soil is affected due to salinity in the state of Rajasthan. Main factors which are responsible for increased soil salinity are excess and faulty irrigation methods, low drainage, and high level of salt.

Saline soil is a soil containing salts in it. The term salinity refers to the presence in soil and water of various electrolytic mineral solutes in concentrations those are harmful to many agricultural crops. Dominant salts in soils are generally consisted of NaCl, $MgCl_2$, $CaCl_2$, Na_2SO_4, and $MgSO_4$. These salts are originally present in soil parent materials and released within soils as result of bedrock weathering. Salts are usually moved into the soil subsurface horizons and may either remain in the soil solutions or precipitate within the root zone (Kapourechal et al, 2013). Most common among these solutes are the dissociated cations Na^+, K^+, Ca^{2+} and Mg^{2+} and the anions Cl^{-1}, SO_4^{-2}, HCO_3^{-1}, and CO_3^{-2}. In addition, hypersaline waters may contain trace concentrations of the elements B, Se, Sr, Li, SiO, Rb, F, Mo, Mn, Ba, and Al, some of which may be toxic to plants and animals (World Bank, 2000). The distinguishing characteristic of saline soil is an electrical conductivity of saturation soil extract of more than 4 dS/m at 25^0C (Richards, 1954).

Surface drainage is the removal of excess water from the surface of the land. This is normally accomplished by shallow ditches, also called open drains. The shallow ditches discharge into larger and deeper collector drains.

In order to facilitate the flow of excess water toward the drains, the field is given an artificial slope by means of land grading.

The Rajasthan Agricultural Drainage Research (RAJAD) project involves the installation of horizontal subsurface drainage (SSD) as a method to restore the productivity of irrigated lands affected by water logging and salinization induced by irrigation operations. A total area of 15,000 hectare has been provided with SSD out of a command of 2,29,000 ha, (RAJAD,1995). One of the main issues is the leaching and transport of soluble constituents from the soil profile to surface waters where downstream water quality may potentially be affected.

The Chambal Command Area (CCA) comprises of an area of 385,000 ha, of which 229,000 ha have been irrigated since 1960. Annual rainfall in the CCA ranges from 600 to 1400 mm, with an average of 740 mm. approximately 85% rainfall occurs during the main monsoon season from July to September. Intensive irrigation takes place from October to April. Water logging and soil salinity problems in the CCA have continued to increase since irrigation was first initiated. The causes of water logging and salinity include canal seepage, excess water from on-farm irrigation practices, and lack of effective internal drainage characteristics of the soils. By 1990, about 20,000 ha of the irrigated lands are found saline.

One of the test sites where soil salinity reclamation was planned by RAJAD in 1991 is the Hatnapur Test site which is located on 69 hectare, bounded by Hatnapur minor, Bhia Road and a main drain. The test site was established in June-July 1993. Corrugated perforated PVC pipes with 100 mm outside diameter with rectangular openings were used for laterals. The drain spacing of 15, 30, 40, 60 and 75 m were tested. The average drain depth was 1.2 m. The soils of the area are classified as Chambal Variant series with grayish dark brown clay in texture in the top 100 cm and clay to clay loam in 100-150 cm depth. The installation was done by excavating trenches (60 cm width) using excavators, and after manual laying of drain pipes in the trenches, the first 40 cm of backfill was placed manually and the remaining with a dozer. There are 19 test plots in which monitoring for soil salinity and effluent quality were done.

II. SOIL SALINITY

The problem of increasing salinity caused by the rise of water table due to lack of proper drainage is considered as a major environmental problem that threatens the capital investment in irrigated agriculture and its sustainability. Drainage has not been given importance as much as irrigation by the farmers as well as the Government Agencies. So there is a great demand for the concerned research and development efforts to reclaim all the salt affected and water logged soils and bring them back to profitable farming with increased agricultural production as well as cropping intensity. The only means to overcome the salinity and water logging permanently is selection and adoption of suitable Sub Surface Drainage systems.(Babu et.al,2008) Reclamation of waterlogged saline soils through installation of subsurface drainage system helps to enhance farm income by increasing land productivity. Both cropping intensity and crop yield increased with decrease in soil salinity (R. Raju et.al, 2015). The main causes of salt accumulation in soils are: (i) use of saline water for irrigation of lands, (ii) seepage from canals, (iii) an arid climate, (iv) evaporation of salty soil waters from the soil surface over shallow and fluctuating water tables and (v) poor drainage. All these factors, either singly or in association with other factors, are responsible for the development of salt affected soils in the world (A.A. Siyal et.al, 2002).

Subsurface drainage improves the productivity of poorly-drained soils by lowering the water table, creating a deeper aerobic zone, enabling faster soil drying and improving the root zone soil layer condition to activate functions of pants roots (Mehdi Jafari-Talukolaee et.al,2016). A well designed subsurface drainage system with reasonable drain space and depth contributes to large ratio of desalination and high crop yield. (X.H. Shao et.al, 2012).

Good drainage design should address both production and environmental goals. Design and management of drainage systems should be tailored to the region and site (Chris Hay, 2010). The major effect of drainage is to alter the route of water loss from the site. In its un drained state, the soil is waterlogged for the majority of the winter, incident rainfall cannot infiltrate, and water leaves as surface runoff or near-surface flow (Armstrong, A. C. and E. A. Garwood. 2001). Research conducted for the last 35 years has shown that subsurface drainage has a significant impact on hydrology and contaminant transport. This can be observed at the field-scale and also at the watershed scale. Impacts are always associated with modifying otherwise natural flow paths (Carlier, J. P., C. Kao, and I. Ginzburg. 2007). The Indian Council of Agricultural research has given priority to control and manage salinity problems that have developed in north-west India. Multi-disciplinary taskforces have recommended installation of subsurface drainage for salinity control, based on design and management techniques developed by the Central Soil Salinity Research Institute (CSSRI), to rehabilitate lands with excess soil salinity. After small-scale studies, large-scale pilot projects were launched to install subsurface drainage in problem areas (Datta, K.K., T. Laxmi, and P.K. Joshi. 2004). Subsurface drainage systems offer one method for lowering water tables, removing dissolved salts, and reducing salinization by purging excess water from root zones. When installed on irrigated lands, subsurface drainage usually lowers the water table and reduces salinity (Swift Current, Saskatchewan-H., Steppuhn, 2005). Subsurface agricultural drainage provides agronomical and environmental benefits in terms of improved crop yield, improved soil trafficability, field operations and reduction in sediment and phosphorus losses from agricultural fields (Priyanka Tiwari, Arun Goel, 2015). The subsurface drainage technology has proved to be a technically feasible and cost-effective tool to combat the twin problems of waterlogging and soil salinity (Datta *et al.*, 2004; Mathew, 2004; Chinnappa and Nagaraj, 2007; Ritzema and Schultz, 2010). High water table and land Salinization in irrigation areas worldwide can often be managed with various forms of sub-surface drainage, but constraints on the disposal of saline drainage water to downstream users and environments often requires on-site management methods (Bruce C. Gill, Alister D. Terry, 2015). Installation of subsurface drainage systems is one of the most common modifications of the agricultural landscape, and while it is well accepted that these systems alter the hydrologic regime (Brandon P. Sloan[a, 1], Nandita B. Basu[b,] , Ricardo Mantilla[a], 2015). Effectiveness of a subsurface drainage system decreases with time, leading to a need to restore the drainage efficiency by installing new drain pipes in problem areas. The drainage performance of the resulting system varies spatially and complicates runoff and nutrient load generation within the fields (Riikka Nousiainen et.al, 2015). Artificial drainage, also known as subsurface or tile drainage is paramount to sustaining crop production agriculture in the poorly-drained, humid regions of the world (K.W. King, N.R. Fausey , M.R. Williams, 2014). Drainage water management (DWM) is promoted as an agricultural best management practice that reduces subsurface drainage volume and thereby the transport of soluble nutrients to streams (Kpoti M.Gunn et.al, 2014). Extensive subsurface drainage could move more water from the watershed to the rivers in the rainfall season, creating more storage capacity in the soils. However, such increase in storage capacity in soils would have a negligible effect in reducing the monthly flow volumes in the following spring (Mohammed M. Rahman et. al, 2014) Salinity and water logging have impacted agricultural production in arid areas for more than 2000 years. The causes of the problems are well known, as are the methods and investments required to manage salt-affected soils and shallow water tables.(Dennis Wichelns[a, ,], Manzoor Qadir[b, c] 2014). Originally the drains were thought to function as interceptor drains and their main effect would stem from intercepting the underground seepage water from the canals in the upland. On the other hand, while assessing the performance of the system, it was observed that drainage discharge and EC of the drainage effluent in all three drains were of the same magnitude (M.V. Manjunatha et.al, 2004). The sustainability of irrigated agriculture in India is threatened by water logging, soil salinity, and alkalinity. To reverse declining agricultural productivity, a combination of surface and subsurface drainage, supplemented by improved irrigation management, has been identified as the most appropriate strategy. But subsurface drainage for salinity control is costly. Therefore, its benefits in terms of sustained agricultural production must be thoroughly investigated to establish its techno-economic feasibility (K.K Datta[a], C de Jong[b, ,], O.P Singh[a]). To ensure the sustainability of irrigated agriculture in the area, technical and financial support is needed and enhanced institutional arrangements including coordination among different federal and provincial government agencies to resolve inter-provincial water allocation and water related issues is required (A.S. Qureshi[a,], P.G. McCornick[b,], M. Qadir[b, 1,], Z. Aslam[c,]). The effects of subsurface drainage on agriculture are analyzed in relation to drain discharge, control of the water table and salt evacuation. The drain discharge depends mainly on external factors (the water balance), whereas the level of the water table can be influenced by the design of the drainage system. Agricultural drainage criteria must therefore be sought in the required degree of water table control, given a certain water balance. To this end, relationships between water table depth and crop production or production factors need to be determined, and critical depth values need to be derived. As the water table fluctuates, a suitable indicator has to be found for it from the depth-duration-frequency relationship. The variable that gives the highest degree of statistical explanation is the most suitable. It can be a long-term, average depth, or an extreme, short-term, shallow depth. The corresponding agricultural drainage criteria are called long-term and short-term criteria (R.J. Oosterbaan, 2003). The study has revealed that reclamation of waterlogged saline soils through installation of subsurface drainage system helps to enhance farm income by increasing land productivity. The study has suggested that the farmers should be made aware about the benefits of this drainage technology to increase crop yield and farm income (R. Raju et. al, 2015).

III. MAIN OBJECTIVES OF THE PROPOSED RESEARCH WORK

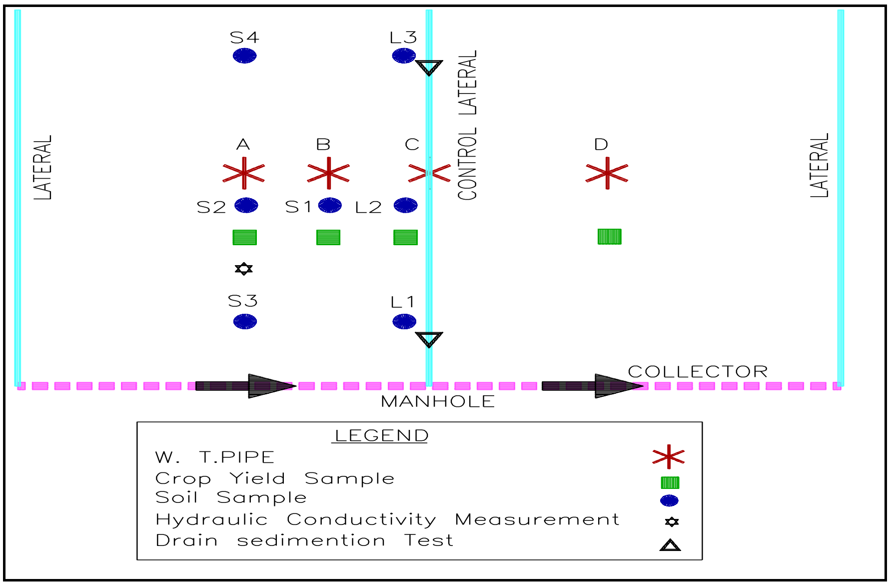
1. Collection of soil samples of highly saline subsurface drainage plot and control plot which were installed in 1993 and monitored for subsequent years up to 1998.
1. Impact of subsurface drainage on soil salinity in 0-30, 30-60, 60-90, 90-120 and 120-150cm of soil depth will be studied at Hatnapur sub surface drainage plot in Chambal command area.
2. The seasonal study of changes in pH, electrical conductivity (ECe), will be conducted to evaluate the soil salinity status of the soil.

3. The seasonal study of changes in Ca^{+2}, Mg^{+2}, and Na^{+} will be conducted to evaluate the cation status of the soil.
4. The seasonal study of changes in Cl^{-1}, CO_3^{-2}, HCO_3^{-1} will be conducted to evaluate the anion status of the soil.
5. Impact of sub surface drainage on irrigated land will be studied to facilitate better yields of the desired crops.
6. Long term impact of the subsurface drainage on soil salinity reclamation will be conducted and recommendations will be made to maintain the soil health for sustained agriculture production in the area.

IV. DETAILED METHODOLOGY

The soil samples will be taken from one location L_2 of each plot (see Figure 2) at the Hatnapur test site. The samples will be collected from 0-30, 30-60, 60-90, 90-120, 120-150 cm of soil depth during pre monsoon season (May-June) for two years.

The samples will be analyzed for ECe, pH, Calcium, Magnesium, Sodium, Carbonate, Bicarbonate by standard laboratory methods and seasonal variations will be observed.



- L2 is located along the control lateral (Lateral with manhole) at 1/2, lengths measured from the downstream end (i.e. from manhole) to the upstream end.
- The soil samples will be taken at soil depths 0-30, 30-60, 60-90, 90-120, 120-150cm by using the soil auger from the selected soil depth. Each sample will be put in a separate polythene bag. The samples will be delivered to Soil and Water Laboratory for detailed analysis of ECe, pH, calcium, magnesium, carbonate, bicarbonate and chloride.

The soil samples will be taken once a year in the months of April-June to represent the pre-monsoon period. The changes of soil salinity at location L_2 will be used to examine the effect of SSD on saline soil reclamation. These results will be compared with earlier results observed during monitoring by Rajasthan Agriculture Drainage Research Project, CAD Kota in collaboration with Canadian International Development Project.

V. METHODS OF ANALYSIS

S.No.	Analysis	Method	References
A.	Water Analysis		
1.	Electrical conductivity	EC will be determined with the help of "solubridge" in water as per method 4b of U.S.D.A. Hand Book No.60	Richards (1954)
2.	pH	pH in water will be determined as per method 3a of Handbook No. 60	Piper (1950)
3.	Ca^{++} & Mg^{++}	Ca^{++} & Mg^{++} will be determined by standard EDTA titration as per method 7 of U.S.D.A. Hand Book No. 60.	Richards (1954)
4.	Na^{+}	Sodium will be determined with the help EEL flame photometer as per method 10a of U.S.D.A. Hand Book No. 60.	Richards (1954)
5.	CO_3^{--} and HCO_3^{-}	Carbonate and bicarbonate will be determined by titration with acid as per method 12 of U.S.D.A. Hand Book No. 60.	Richards (1954)
6.	Cl^{-1}	Chloride will be determined by titration with silver nitrate as per method 13 of U.S.D.A. Hand Book No. 60.	Richards (1954)
7.	SO_4^{--}	Sulphate will be determined by precipitation as barium suphate as per method of U.S.D.A. Hand Book No. 60.	Richards (1954)
B.	Soil Analysis		
1.	pH(Saturation paste)	Saturation soil paste will be prepared by distilled water and extract will be obtained as per method 3a of U.S.D.A. Hand Book No. 60.	Piper (1950)
2.	Electrical Conductivity	ECe will be determined with the help of "solubridge" in soil water saturation extract as per method 4b of U.S.D.A. Hand Book No.60	Richards (1954)

3.	Soluble cations:		
(i)	Ca^{++} & Mg^{++}	Ca^{++} & Mg^{++} will be determined by standard EDTA titration as per method 7 of U.S.D.A. Hand Book No. 60.	Richards (1954)
(ii)	Na^{+}	Sodium will be determined with the help EEL flame photometer as per method 10a of U.S.D.A. Hand Book No. 60.	Richards (1954)

REFERENCES

[1.] A.A. Siyal, A.G. Siyal and Z.A. Abro. Salt affected soils their identification and reclamation. Faculty of Agricultural Engineering, Department of land and Water Management Sindh Agriculture University,Tandojam, Pakistan. Published in Pakistan journal of Applied Sciences, 2002.

[2.] Armstrong, A. C. and E. A. Garwood. 2001. DOI: 10.1002/Hyp.3360050204. *Hydrological Consequences of Artificial Drainage of Grassland.* DOI: 10.1002/hyp.3360050204.

[3.] A.S. Qureshi[a,], P.G. McCornick[b,], M. Qadir[b, 1], Z. Aslam[c,]

[4.] [a] International Water Management Institute (IWMI), c/o Iranian Agricultural Engineering Research Institute (IAERI), P.O. Box 31585-845, Karaj, Iran

[5.] [b] International Water Management Institute (IWMI), P.O. Box. 2075, Colombo, Sri Lanka

[6.] [c] Nuclear Institute of Agriculture and Biology, Faisalabad, Pakistan.

[7.] Babu G. Kishore, Chandra S. Ramesh, Reddy K.Yella, Rao G.Subba and Radha Y., 2008, Impact of open sub surface drainage on reclamation of waterlogged and salt affected soils, A.P. Water Management Project, Bapatla.

[8.] Brandon P. Sloan[a, 1], Nandita B. Basu[b,], Ricardo Mantilla[a], 2015. Hydrologic impacts of subsurface drainage at the field scale: Climate, landscape and anthropogenic controls

[9.] [a] IIHR-Hydroscience and Engineering, University of Iowa, C. Maxwell Stanley Hydraulics Laboratory, Iowa City, IA 52242, United States

[10.] [b] Civil and Environmental Engineering, and Earth and Environmental Sciences, University of Waterloo, 200 University Avenue West, Waterloo, ON N2L 3G1, United States.Received 26 March 2015, Revised 7 October 2015, Accepted 10 October 2015.

[11.] Bruce C. Gill, Alister D. Terry, 2015. 'Keeping salt on the farm'—Evaluation of an on-farm salinity management system in the Shepparton irrigation region of South-East Australia Department of Economic Development, Jobs, Transport and Resources—Agriculture Research and Development Division, Tatura, Victoria, Australia Received 6 May 2015, Revised 12 October 2015, Accepted 14 October 2015, Available online 7 November 2015.

[12.] Carlier, J. P., C. Kao, and I. Ginzburg. 2007. Field *Scale Modeling of Subsurface Tile Drained Soils using an Equivalent-Medium Approach*. Journal of Hydrology, Volume 341, Issues 1-2, 20 July 2007.

[13.] Chahar B. R. and Vadodaria G. P., 2008, Steady subsurface drainage of homogeneous soils by ditches, Proceedings of the Institution of Civil Engineers Water Management , December 2008, Issue WM6, pp. 303–311

[14.] Chris Hay, Agricultural Subsurface Drainage Systems: Fundamentals, Benefits and Impacts, and Design. Extension Water Management Engineer Ag & Biosystems Engineering South Dakota State University. December 15, 2010

[15.] Datta *et al.*, 2004; Mathew, 2004; Chinnappa and Nagaraj, 2007; Ritzema and Schultz, 2010.

[16.] Datta, K.K., T. Laxmi, and P.K. Joshi. 2004. *Impact of subsurface drainage on improvement of crop production and farm income in north-west India.* Irrigation and Drainage Systems.

[17.] Dennis Wichelns[a, ,] , Manzoor Qadir[b, c] 2014. Achieving sustainable irrigation requires effective management of salts, soil salinity, and shallow groundwater. Available online 11 September 2014.