INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

Centre of Studies in Resources Engineering

S Y N O P S I S

of the Ph.D. thesis entitled

Development of Techniques in Improving Irrigation Water Quality Parameters and Validation

Proposed to be submitted in

Partial fulfilment of the requirements for the Degree of

Doctor of Philosophy

of the

INDIAN INSTITUTE OF TECHNOLOGY, BOMBAY

by

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1. Introduction

Globally, 65% of the pumped groundwater is used for irrigation, 25% as drinking water supply and 10% for industries. It is the source of irrigation and drinking water in Saudi Arabia (100%), Tunisia (95%) and Morocco (75%). Agriculture dependency (groundwater) is 50% in India, 80% in Spain, 84% in South Africa and 90% in Libya. Rain-fed agriculture relies on the groundwater for its supplementary irrigations. 70% of applied irrigation water is consumed as evapotranspiration leaving the salt encrustation. They deposit more than 640 mg/litre and 3 to 5 tons of salt is deposited/irrigated ha/ year. Total dissolved solids (TDS) onto the soil and lead them to degrade over a period. The global annual cost of salt-induced land degradation in irrigated areas (as crop production losses) is estimated to be around US$ 27.3 billion. 80% of the agricultural land worldwide is under rain-fed agriculture that produces low yield levels and high on-farm water losses. About 230 km^3 of groundwater is pumped out per year in India through 21 million dug-wells and tube-wells. About 39% of the wells are showing a decline in groundwater level. 1071 watersheds out of 6607 in India, are grouped as Over-exploited (Kulkarni 2000). Frequent dry spell occur during Kharif season (Chavan et al, 2009) needs the supplementary irrigation from groundwater to avoid the wilting of the crop, in the early growth stage and maturity stage of the crop. The dominant crops grown during the Kharif, Rabi and summer are maize, wheat & onion respectively- The total quantity of water required to be pumped out for flood irrigation is 8500 m^3/ha for maize crop. 90% of the current population in developing countries depend on a predominantly rain-fed-based rural economy and supplemental irrigation during short dry spells can lead to large increases in water productivity. The rapid decrease in groundwater level and increased salt concentration result in degradation of soil and decrease in crop yield. The salt deposition not only increase soil salinity but also affect drip delivery system. The water level fluctuations in hard rock aquifers show an increased concentration of groundwater salts and its effects on soil health, crop yield and irrigation delivery system than other aquifer types. Hence, their aquifer characteristics of the said regions need to be assessed for the quality of groundwater (CGWB report, 2018) prior to irrigation and take necessary steps.

2. Literature review

The quality of groundwater varies from season to season and place to place depending on the depth of water table, extent and composition of dissolved solids. The hydrological imbalance has triggered the geochemical processes expressed as a spatiotemporal variation in groundwater chemistry (Matthess 1982; Kumar et al. 2006). Groundwater contains dissolved salts and traces elements from the natural weathering. Groundwater contains dissolved salts and traces elements from the natural weathering. Groundwater chemistry depends on geology, the degree of chemical weathering of rock types, and quality of recharge water (Singh Kuldip et al. 2011). In recent years, an increasingly significant threat to groundwater quality is from human activities (Deshpande and Aher, 2012). Water quality for irrigation delivery system required specific criteria i.e. salt contents are in below 0.1 ppm as far as Mg and Fe concern whereas pH should be below 7.0 and EC must be below 0.8 (Hopkins, Br et.al,2007). The most critical factor in agriculture is the prediction and managing and forecasting crop production using low-quality irrigation water. There is a need to optimize the use of groundwater, improve the quality to permissible limits and apply as supplementary irrigation in preventing long-term impacts. The water treatments methods such as Oxidation, Coagulation, Flocculation, Sedimentation, Granular media filtration are costlier technologies affordable for limited use for drinking water. In the case of low-quality irrigation water the magnetic water treatment is cost-effective for low-quality irrigation water use. There is a positive impact of magnetic treatment of irrigation water on the plant, water and soil (Surendran et.al,2016). Magnetic treatment method uses Faraday's law of magnetic flux is found to be one of the best alternative wastewater treatment (Zaidi, Nur,2014).

It is reported that even a low magnetic field can change the water (Amiri and Dadkhah 2006) density, salt solution capacity, pH, electrical conductivity, dielectric constant etc. The magnetized water can improve water productivity (Maheshwari & Grewal 2009) and crop yield; increased germination percentage of seeds (Matwijczuk et al 2012), emergence rate (Podleoeny et.al 2004), and root growth (Turker et.al 2007). The benefits of magnetically treated water depend upon the plant species, pathway in the magnetic unit and flow rate (Gabrielli et.al 2001). Magnetic fields change the physicochemical properties of water (Aliverdi et.al 2015; Hozayn et.al 2016).

3. Motivation

The farmers are earning their livelihood using the best available resources including water under duress in Asia. Globally, most of the areas in the semi-arid and arid regions, the groundwater has quality/suitability issues. The usage of poor quality water has turned the soil into saline at several places in the field making it unsuitable for cultivation. The application of improved water quality could minimize the rate of soil degradation and increase crop productivity. The precise location of salt encrustation/indications by leaf is required for treatment. Low flying and high resolution (1cm) airborne systems provide precise information for treatment. Cost of the entire activity (identification, treatment) should be minimum. The present agriculture practices need to be prepared for changes in climate.

4. Objectives

Considering the growing of supplementary irrigation requirements with time in meeting the food security and availability of poor quality groundwater for irrigation, the objectives of this study are:

- Identify the groundwater quality parameters that affect the crop growth/yield in a semi-arid region.
- Develop method and instrument to reduce parameters that harm the plants/crops and validate it.

5. Methodology

- Information on the water quality (hard rock aquifer) of irrigation and the damages inflicted on the soil, crop growth, distribution system etc., spread over semi-arid and arid regions were collected in understanding the impacts.
- A device that could reduce the salt content in the water was developed using electromagnetic methods.
- Field trials of the device were carried out in the agriculture plots at Maharashtra (Basalt), Telangana (Hyderabad), Karnataka (Bangalore), Tamil Nadu (Salem) (Gneissic aquifer), Rajasthan (Jodhpur) and Gujarat (Bhuj Sedimentary aquifer).
- The device was positioned in the water delivery system set-up in the field and inlet and outlet water samples were collected and tested (standard procedures) for its chemical properties.
- Samples were analyzed using ion chromatography and scanning electron microscope in assessing the salt crystals and ionic concentrations. Soil condition prior to seeding, crop growth at 1,2,3 & 6 months were monitored (grown with treated and untreated water flood or drip irrigation) for indications of degradation in the soil surface, leave dimensions, crop area etc., using drones.
- Drone images at 10 to 40m above the surface were collected in demarcating the patches of salt encrustation and crop growth indicators for localised treatment.
- Based on the indications, management practices were suggested.

6. Impacts of water quality on soil, plant and delivery system

The impacts of irrigation water quality on soil health – infiltration rate is altered, non-availability of nutrients, decrease in porosity and water holding capacity, impact on soil aeration and soil drainage; irrigation delivery system - clogs lateral, dipper and foggers, uneven water application, corrosion and life span of system; and crop growth- stunted growth, leaf burn and interveinal chlorosis and vulnerable to diseases. **Figure 1 and 2** show the salt encrustation on the soil surface (Aurangabad) in the vicinity of drip irrigation and blockage of nozzles as well the salt encrustation in flood irrigation system.

Figure 1: Salt accumulation in and around drip irrigation system

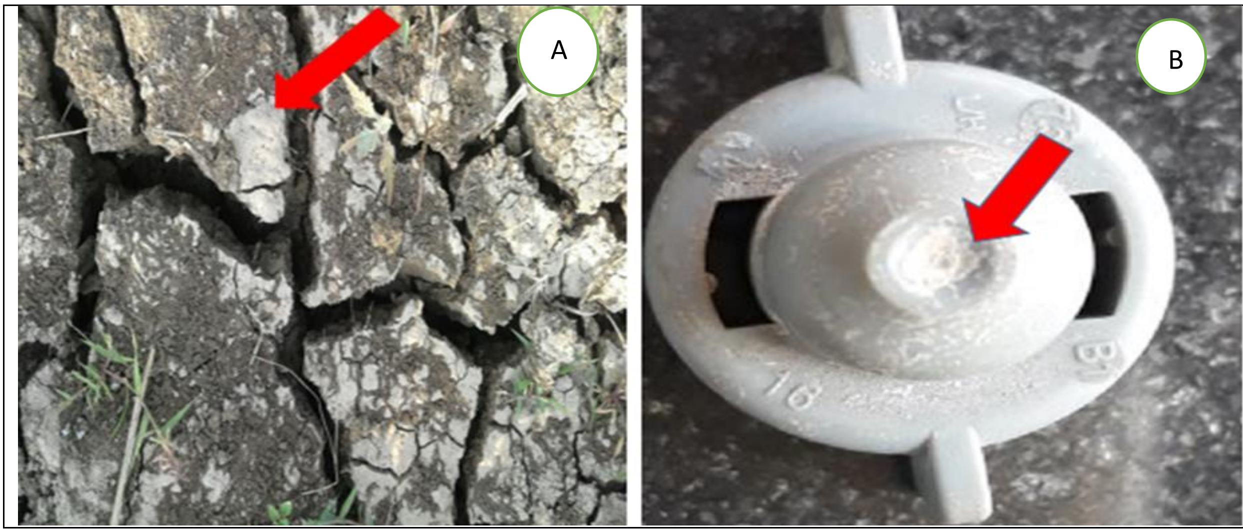

Figure 2: Salt encrustation on soil from flood irrigation (A) and accumulation in outlet of emitter (B)

In order to save the crop and their livelihood farmers use poor irrigation quality water. Severe restrictions on use of water – pH >8.0; Dissolved solids (mg/l) >2000; Suspended solids (mg/l) >100; Manganese (mg/l) >1.5; Iron (mg/l) >1.5; Hydrogen sulphide (mg/l) > 2.0; and Bacterial populations (maximum number/ml) >50000 (Nakayama 1982). Continuous use of water grouped as severe restrictions, the water user has experienced soil and cropping problems or reduced yields as listed above. Higher percentage of soluble salts injure roots, interfere with water and nutrient uptake. Salts in plant leaf margins that cause burning of the leaf edges. High alkalinity affect the pH of the growing medium, interfere with nutrient uptake and leading to nutrient deficiencies which reduce plant health. During low water level periods the concentration increases and available quantity is irrigated to save the crop. Many of cropped areas were degraded and abandoned. There is need for the quality of water that is used to avoid permanent soil degradation.

7. Ground water quality

There is low sustainability of groundwater resources in the central plateau region (Maharashtra, Madhya Pradesh, and Chhattisgarh) and southern peninsular region (Andhra Pradesh, Telangana, Goa, Karnataka, Kerala, and Tamil Nadu) and the groundwater potential is low in these hard rock aquifers (Basalt, granite gneiss, schists, Charnockite etc.). The continuous application of poor quality water led the permanent soil degradation and replacement of irrigation system. Groundwater is used excessively for irrigation and most of critical blocks, where ground water development is prohibited are in this area. The high air temperature and humidity contributes to higher evaporation losses and reduce surface water available for recharging groundwater. Even though the available water is used to save the crop for a season, their productivity and progressive soil salinization make the land unsuitable for agriculture over a period of time and their meagre livelihood is stopped. Most of the poor water quality is reported from hard rock aquifer areas which are in the semi-arid and arid regions. Most of the districts in India are experiencing water salinity (CGWB 2015).

The suitability of water quality for use is judged on the potential severity of problems that can be expected to develop during long-term use. The Irrigation water samples were collected from inlet and outlet of the device during its operation adopting standard protocol. The samples were analysed for electrical conductivity (EC), pH, and total dissolved solids (TDS); and major cations like calcium, magnesium, sodium, potassium, and anions including bicarbonate, carbonate, chloride, nitrate, and sulphate – adopting the standard methods of the American Public Health Association APHA (23rd edition,2017) . The water samples were analysed at CARS laboratory at Marathwada Institute of Technology, Aurangabad. IS: 11624,(1986) code has classified Irrigation water quality as Bad [60 – 80 % of Na, 2250-4000 Electrical conductivity (μS/cm); >26 SAR and 2.5-30 of RSC (meq/l)] and very bad quality [(> 80% of Na, > 4000 of Electrical conductivity (μS/cm), > 26 of SAR and > 3.0 of RSC (meq/l)]).
Table 1 shows the irrigation water quality parameters that are being used.

Table 1. Groundwater quality parameters in salinity affected areas

Aquifer	Sedimentary	Hard rock (Granite, Gneissic)				Basalt			FAO / ISI
Parameter	Bhuj	Hyderabad	Bangalore	Hosur	Nammakal	Aurangabad	Ahmednagar	Baramati	
pH	7.73	8.12	7.25	8.45	7.98	7.64	8.50	7.18	6.5-8.4
EC(mS/cm)	17.80	9.11	5.27	7.18	3.01	2.27	2.20	2.48	< 1.0
Na (meq/l)	12.0	5.26	13.17	22.10	9.2	11.03	2.91	10.16	1.0-3.0
Ca (meq/l)	27.11	14.3	19.16	13.52	3.08	2.00	22.0	5.00	1.0-3.0
Mg (meq/l)	15.00	16.21	20.0	7.29	11.32	2.00	4.00	10/30	1.0-3.0
K (meq/l)	1.02	8.0	3.0	11.36	0.04	0.09	1.79	0.02	1.0-10.0
CO_3 (meq/l)	0.00	1.12	0.00	0.00	1.12	2.80	10.00	0.00	<1.0
HCO_3(meq/l)	0.50	3.08	5.17	4.13	4.69	7.20	0.00	0.00	< 2.5
Cl (meq/l)	35.44	26.34	35.44	35.44	35.44	4.00	12.00	13.00	< 2.0
SO_4 (meq/l)	2.98	5.12	3.74	2.01	2.98	1.12	8.70	0.78	< 2.5
SAR(meq/l)	16.10	13.50	6.23	4.12	10.50	7.80	0.81	3.71	< 3.00
RSC(meq/l)	3.00	2.04	2.11	5.16	0.00	6.00	0.00	0.01	<1.25

The concentration of charged ions in the water is one among the reasons for precipitation. Their concentration was determined using Ion chromatography technique. It provides a simple, rapid and accurate determination of F^-, Cl^-, Br^-, NO_3^-, PO_4^{3-}, SO_4^{2-}, Na^+, K^+, Ca^{2+} and Mg^{2+} in ground water samples. The concentration in the treated and untreated samples with certified reference standards is shown in **Table 2** was carried out at Thermo Fisher Scientific, Powai. The reduction in the harmful cations are more than 70% and anions are above 45%.

Table 2. Ion Chromatography studies on irrigation water - Baramati

Sample	Cations (mg/L)			Anions (mg/L)			
	Na	Mg	Ca	Cl	NO_3	CO_3	SO_4
Standard	30	10	6	0.03	1.03	10.7	1.49
Untreated	23.8703	6.0035	6.2596	47.46	127.91	194.58	1236.45
Treated	6.2691	1.7871	1.8701	27.8	66.97	88.77	704.69
Change	- 74.85%	- 70.23%	- 70.14%	- 41.42%	- 47.64%	54.38%	- 43.01%

Normal water comprises of water molecules that are loose and in chaotic form of attraction. Scanning Electron Microscopy with Energy Dispersive (SEM-EDS) - Spectral image analysis was used in understanding the changes in water molecule and its chemical parameters. The field emission gun-scanning electron microscope (FEG-SEM) of model JFM-7600 F available at SAIF facility centre, IIT, Bombay was used. The magnification range of 1,000,000 X to arrive at accuracy of molecular crystals in the water. The crystal structures observed for Na as Albite, Mg as MgO, Si as SIO_2, S as FeS_2, Cl as KCL, Ca as Wollastonite. Presence of dispersed salt crystals in the untreated water sample and clustering of crystals after treatment that are shown in **Figure 3**.

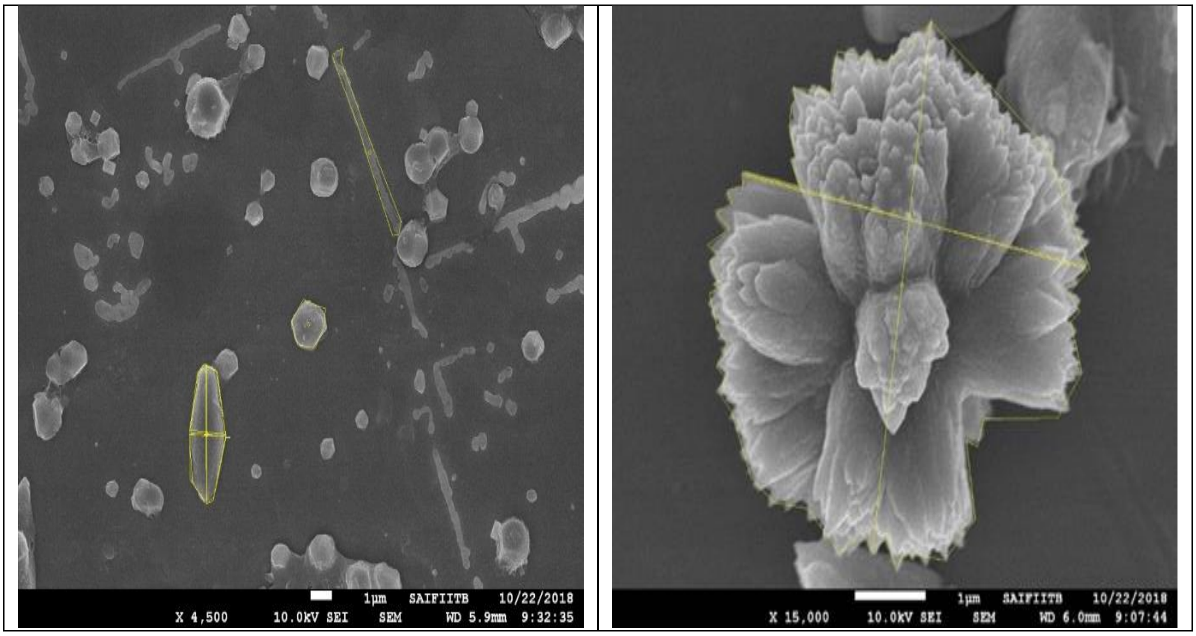

Figure 3: Dispersion salt crystals (before) and clustering of crystals (after treatment) under 4500 and 15000 X magnification through SEM-EDS analysis of irrigation water from Baramati.

This confirms the hypothesis that the ion of formerly dissolved minerals and micro crystals move with the water in suspension (Zhou et al., 2000; Xiao Feng and Bo, 2008). The energy for this entropy reduction is provided by the kinetic energy of the moving water. The magnetic fields in hard water is characterized by the scarcity of nucleation centres; super-saturation develops and accordingly the minerals start to solidify at the substrate in the form of dendritic crystallization, which indicates the scaling of pipes (Fathi et al., 2006)

7. Development of water quality improvement device

The existing methods of water treatments are – a) physical / mechanical conditionings such as magnetic water conditioner that deactivate the anions and filtration of water entraps the turbid or physical particles. 2) Chemical –water treatments such as ion exchange by means of Ca and Mg, use of softening agents, lime, pH adjustments need continuous chemical addition required and effective for stored water. 3) Water blending is effective when there is the availability of an alternate source. Magnetic treatment restructures the water molecules into tiny and uniform clusters that can easily enter the passageways in plant and animal cell membranes. It influences crystallization process such as association, dissociation and nucleation rates. It can effectively prevent and remove scale deposits in pipes and water structures. The effective magnetic treatment depends on flow rate through the apparatus and chemical parameters (hardness and pH). Simple, cost effective method / device that could be transported to fields are ideal for supplementary irrigation in arid and semi-arid region water management. Water quality improvement device developed consist of an electrolysis unit, dynamic pulse unit and the electromagnetic unit is shown in **Figure 3.** This device works on the basis of, ionization of dissolved solid using cathode and anode, electrolysis process of water with the help of 50 kHz dynamic pulse current and energization of the cations through 1200 Gauss electromagnet respectively.

The water inflow enters into the electromagnetic unit and flows amidst the cathode and anode coils. The electrolysis process begins with the ionization of dissolved solids from the water. The ionized water moves on to the dynamic pulse unit where 50 kHz frequency generated by 440V current and works with Faraday's law of EMF phenomenon. Deactivation of anions of water takes place in the dynamic pulse unit. Deactivated anions of water enter into an electromagnetic unit having electromagnets energize the cations and flows out. The processed water outflows through the pipeline are applied irrigation set up. Irrigation water quality parameters were analysed before and after the trial. The modified water treatment device consists of electrolysis and electromagnet by means of cathode and anode of copper coil and 2000 G electromagnet. Total device having three sections and 2-inch diameter of inflow-outflow connection defined whereas the total length of the device approximately four feet. 2 HP submersible pump with the discharge of 100 liters/minute from the well. The input pressure was adjusted to 1 kg/cm^2 by pressure control valves to suit the rate of inflow of the device.

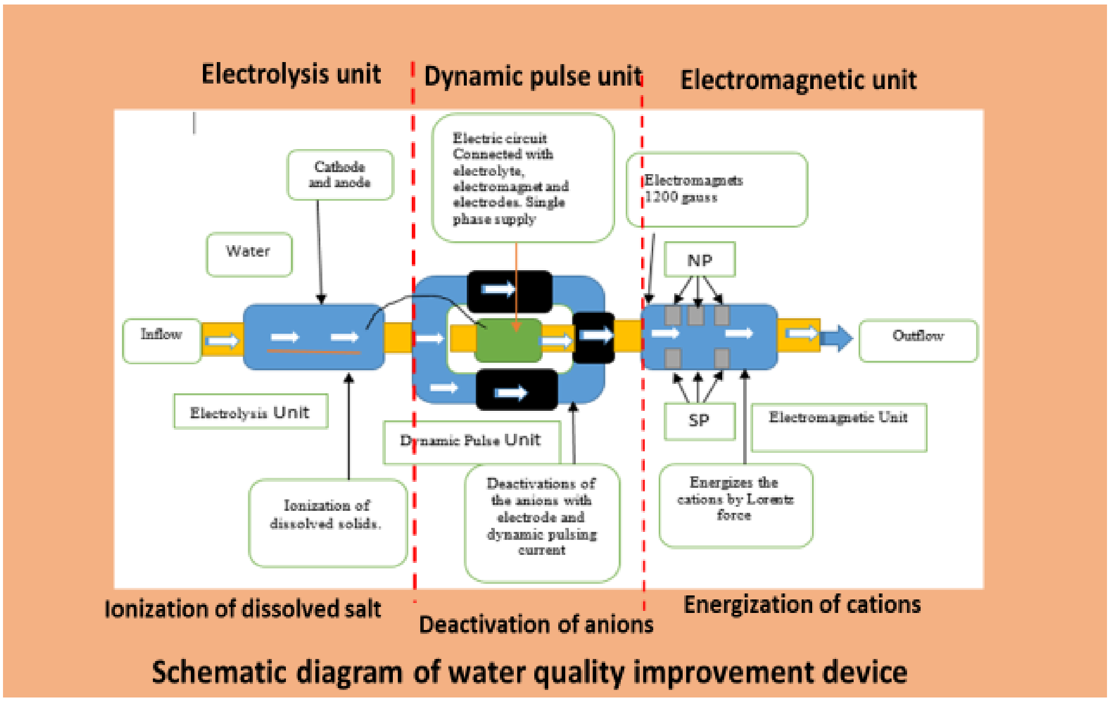

Figure 3: Schematic Diagram of the electrolysis-electromagnetic device

In the electrolysis unit, ionization of dissolved solid starts with the help of cathode and anode.. The decomposition of hydrogen and oxygen take place.

$$2H_2O + \text{electrical energy (+ heat energy)} \longrightarrow O_2 + 2H_2$$

Passage of electric potential through water causes positive ions. Hydrogen ions move towards the cathode and negative ions like hydroxide ions OH^- move towards the anode (+ve).

In the dynamic pulse unit, 50KHz current passes through the water and deactivates the anions.

$$EMF = -N\frac{\Delta\Phi}{\Delta t}$$

Where, N= number of turns; Φ=BA=magnetic flux; B=external magnetic field; A=Area of the coil

HCO_3^- + dynamic pulse current $\longrightarrow$ Deactivation of anions (HCO_3^+)

After deactivation of anions, water goes to the electromagnetic unit where the force gets generated on the cations that help to energize the cations (Ca^{2+}). In treated water the cations and anions that reactive are reduced (ref. Table 2) and dispersed salt crystal are clustered (ref. Figure3).

8. Field validation

In order understand the effects of magnetic treated water on quality of water, prevention and elimination scaling in distribution system, soil, seed germination, leaf area, plant growth, and crop Yield. Field trials using the developed device and in presence of farmers (stake holder) were carried out having different climatic zones, aquifer characteristics, and agriculture practices. Maize and sugar cane crops growing at agricultural plots (practising flood and drip irrigation) drawing groundwater from hard rock aquifers (Deccan volcanic basalt, granitic gneisses, sedimentary rocks) located in semi-arid to arid region were carried out. They use < 75% of irrigation from the groundwater (poor quality). The soluble salts from weathering of rocks tend to accumulate in the soils. Due to low rainfall and high evaporation in these regions, the groundwater circulation is slow, resulting in high salinity. The inflow from the pump is attached with the irrigation well regulated at 100 liters/min. Filtration unit was attached prior to the device that removes the suspended particulate matters. A pressure gauge was attached to the unit controls the pressures at 1 kg/cm^2. The retention time of water within the device is about 6 minutes. 0.25 unit/hr. of electricity consumption. The device was installed in between screen filter and the main pipeline as shown in **Figure 4** by means of the coupling device. Soil quality of the plot, irrigation water quality of inflow from supply source (well) and out flow to plants were analysed before and completion of trials. It is observed that 4 hours (maximum) of pumping fulfills the irrigation requirement of crops over 1 acre.

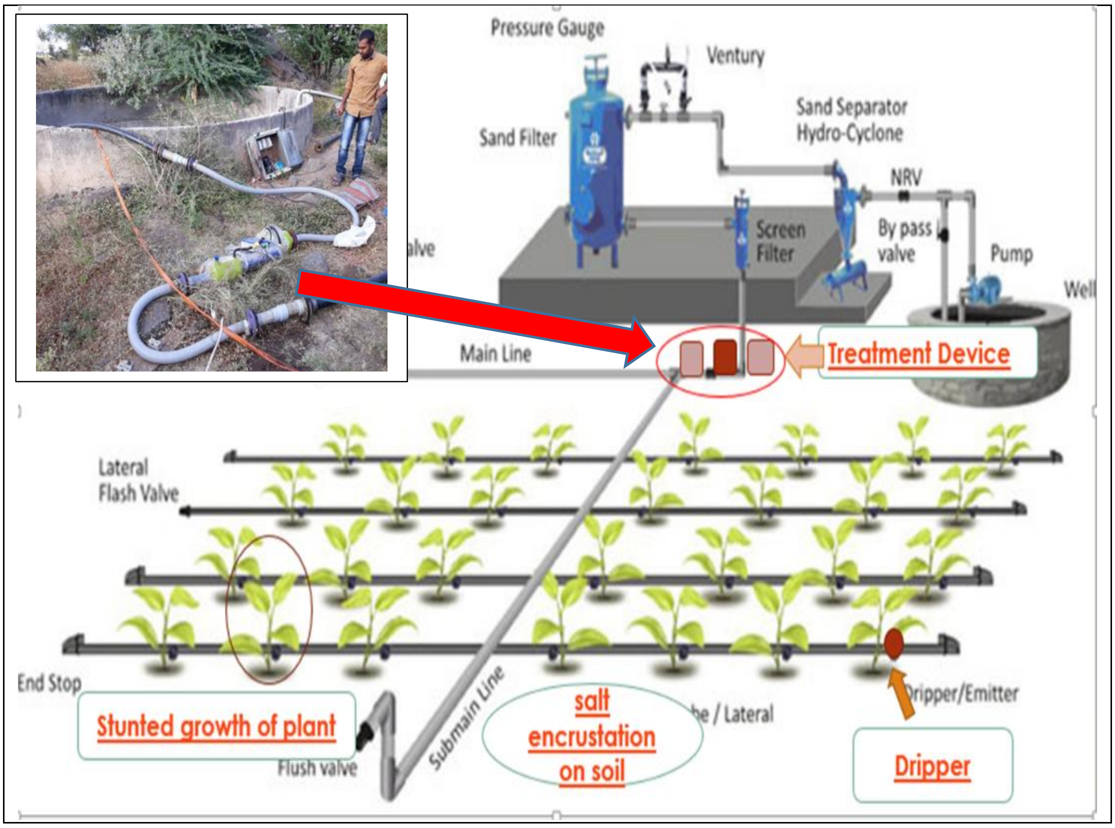

Figure 4: Device installation in irrigation system

The efficiency of the instrument in terms of chemical properties was assessed by analysing the water samples were analysed at the end of every irrigation and also successive irrigations (**Table 3**) and dynamically at time setup during an operation (**Table 4**).

Table 3: Treated irrigation water quality before and after treatment on successive irrigations

Sr. No.	Parameter	2/9/2016		15/10/2016		26/11/2016	
		Inlet	outlet	Inlet	outlet	Inlet	outlet
1	pH	8.64	8.65	8.55	8.60	8.44	8.47
2	EC (mS/cm)	0.62	0.63	0.58	0.58	0.46	0.48
3	Sodium(mg/L)	26.80	26.78	25.80	23.20	23.20	20.20
4	Potassium(mg/L)	124.70	125.40	136.70	119.80	119.80	117.70
5	TDS	260.00	259.00	243.00	243.00	133.30	132.11
6	Calcium(mg/L)	60.00	58.00	53.00	46.00	46.00	40.00
7	Magnesium(mg/L)	78.08	75.88	70.06	69.87	62.87	62.81
8	Carbonate	60.00	60.18	30.00	30.00	30.00	26.00
9	Bicarbonate(mg/L)	451.40	450.20	467.22	465.12	375.17	371.00
10	Chlorides(mg/L)	156.20	156.00	178.35	177.30	136.00	136.20

Table 4: Quality of water over continuous treatment

Chemical properties of water								
Step	Time	pH	EC(mS/cm)	Ca(ppm)	SO_4(ppm)	Cl (ppm)	CO_3(ppm)	HCO_3(ppm)
	Inlet water reading							
0	12.00	7.73	1.864	60	66.8	354.5	60	475.8
	Outlet water Reading							
1	12.30	7.74	1.86	52	65	354.5	60	427
2	13.00	7.78	1.826	52	66.6	283.6	48	451.4
3	13.30	7.82	1.815	48	63.7	241.1	60	366
4	14.00	7.84	1.662	48	70	226.9	60	366
5	14.30	7.89	1.661	48	96.3	198.5	48	390.4
6	15.00	7.99	1.659	44	106	198.5	60	366
7	15.30	8.08	1.658	44	96.1	184.3	48	390.4
8	16.00	8.09	1.654	40	95.6	184.3	48	378.2
9	16.30	8.1	1.651	40	92.4	184.3	36	402.6
10	17.00	8.1	1.649	40	90.4	141.8	36	402.6

Q=100 lpm, 2 HP submersible pump, Pressure=1 kg/cm^2 Location: MIT Terrace Farm

The capability of magnetically treated water can re-dissolve old observed scale deposits. Treatment has helped for better mobilization and transportation of nutrients. It is summarized that poor quality water can be improved in its chemical property and **Table 5** shows the percentage of improvement individual parameters, as observed from the trial sites.

Table 5: Demonstrated capability of instrument in improving irrigation water quality

Parameter	Aurangabad			Baramati		
	Before	After	Change %	Before	After	Change %
pH	7.99	7.52	- 5.88	7.18	7.19	+ 00.14
EC (mS/cm)	1.55	1.38	- 10.97	2.48	1.47	-40.73
Na (mg/L)	104.0	103.0	- 0.96	10.16	2.11	-79.23
K (mg/L)	2.3	3.0	+ 30.43	0.02	0.03	+ 50
Ca+Mg (mg/L)	85.4	97.6	- 14.29	-	-	-
Ca (mg/L)	120.0	68.0	- 43.33	5.00	1.83	-63.40
HCO_3 (mg/L)	561.2	366.0	- 34.78	7.40	3.00	-59.46
Chloride (mg/L)	284.0	241.4	- 15.00	13.00	4.00	-69.23

The salt loading from the poor quality per irrigation is 10249.2 kg/acre (TDS 1314 mg/L), 4056 kg/acre (520 mg/L), 58500 kg/acre (7500 mg/L), 11232 kg/acre (1440 mg/L), 12285 kg/acre (1575 mg/L) in Akola, Aurangabad, Jalna, Ahmednagar and Baramati respectively and 11-13% of this load is reduced by using the device.

Crop growth (salt deposits, plant height, fruits) related observations were carried out by irrigating the same crop with treated and untreated water is shown **Figure 5**.

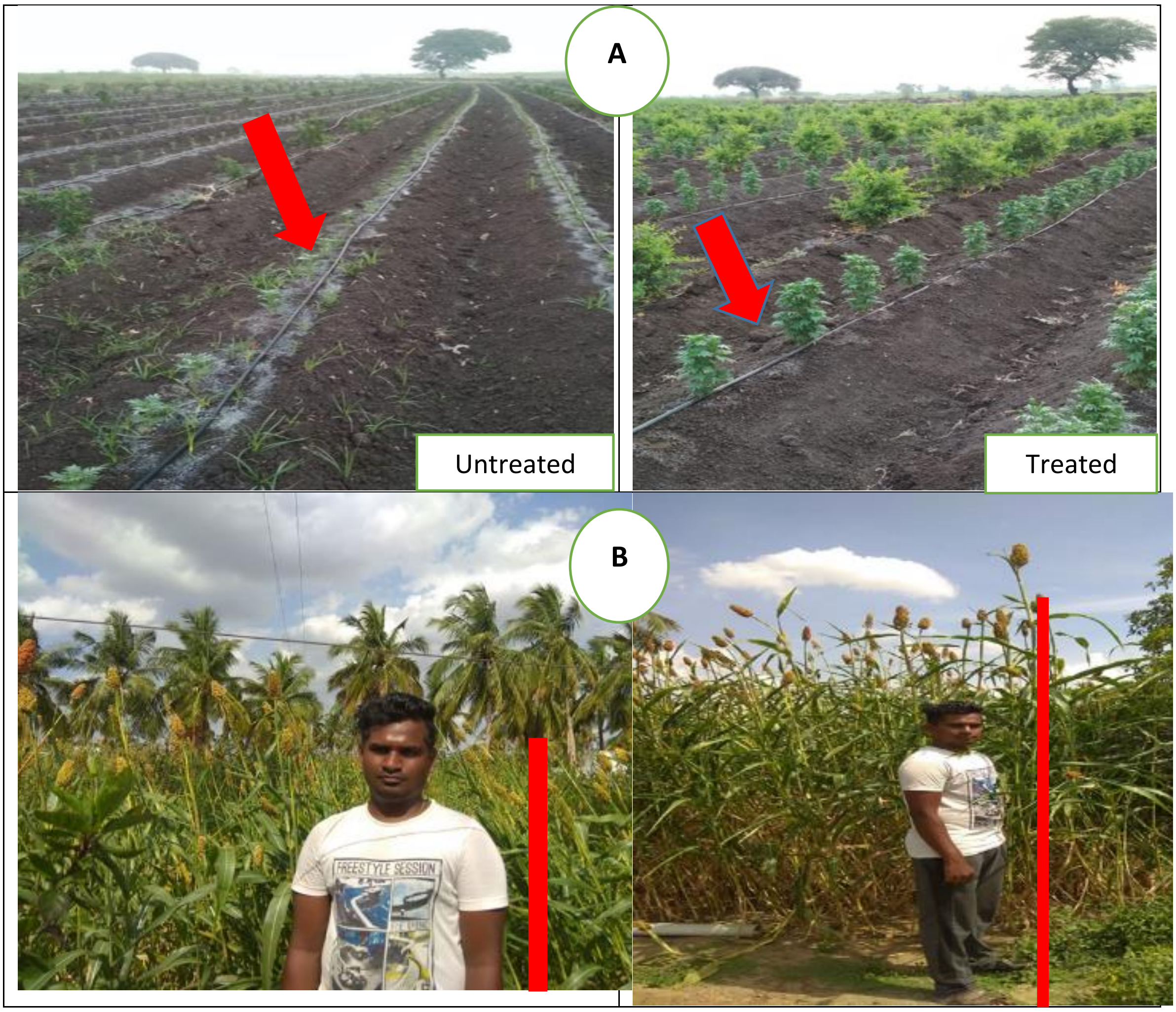

Figure 5. Crop Growth with treated and untreated irrigation water – a) salt deposition in drip irrigation system, b) difference in height and fruits.

The cost effectiveness for farmer was estimated by considering the operational cost and benefit in the form of increased crop yield. It is observed that if it is used for 5acres of Maize in Aurangabad region, it fetches 75% of total cost of the device, in addition to benefits from dairy animals and poultry birds.

10. Drone observation of surface soil and crop

In order to assess the real-time information and precise visualization of changes in effect of treated and untreated irrigation water on soil and crop growth for selective treatment, drones were used. High ground resolution satellite images could not record the micro-level information on salt-affected patches (when it is not cultivated) and plant leaves cover the surface encrustations. Hence, indications of leaves need to be identified. Drones flown at different heights from surface (5,1,5,20 and 25ft). Drone model Phantom 4 PRO V 2.O coupled with sensor1" CMOS and 20M effective pixel used for this study. Thickness and areal extent of salt encrustation on soils (**Figure 4**) and stunted growth of sugarcane (treated and untreated irrigation water) and ground conditions (**Figure 5**) is needed for selective treatments.

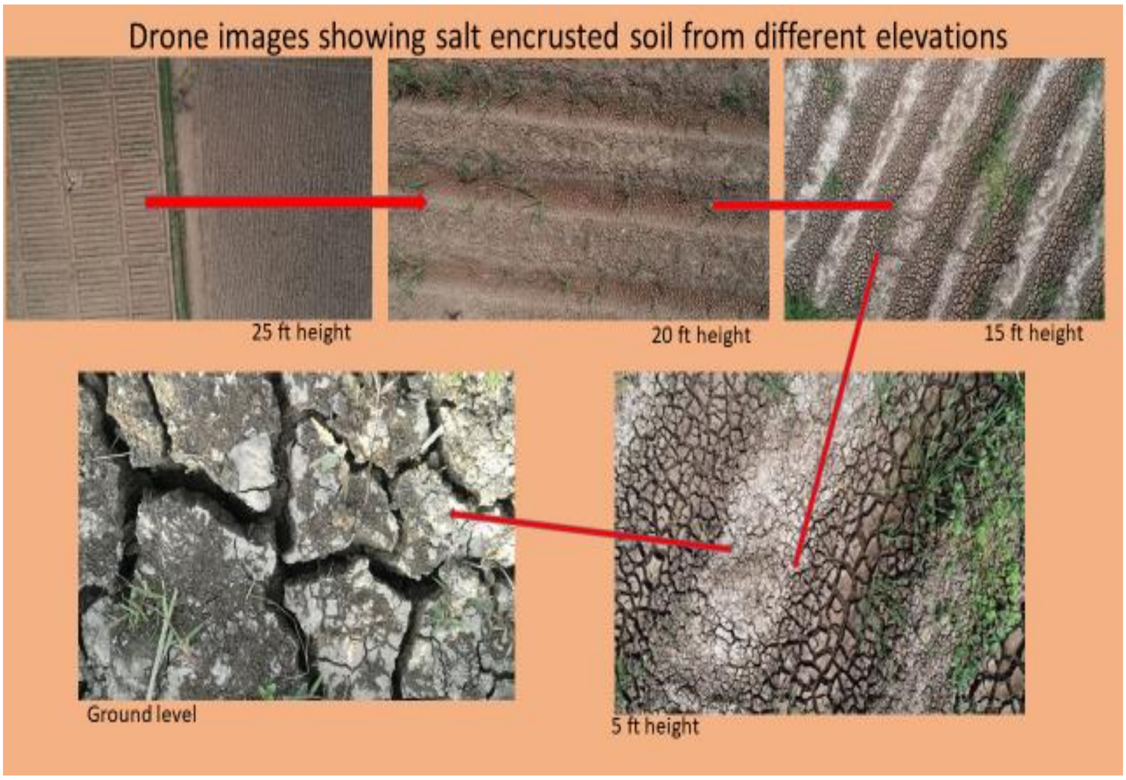

Figure 6. Drone image showing the deauls of salt encrustation from different heights

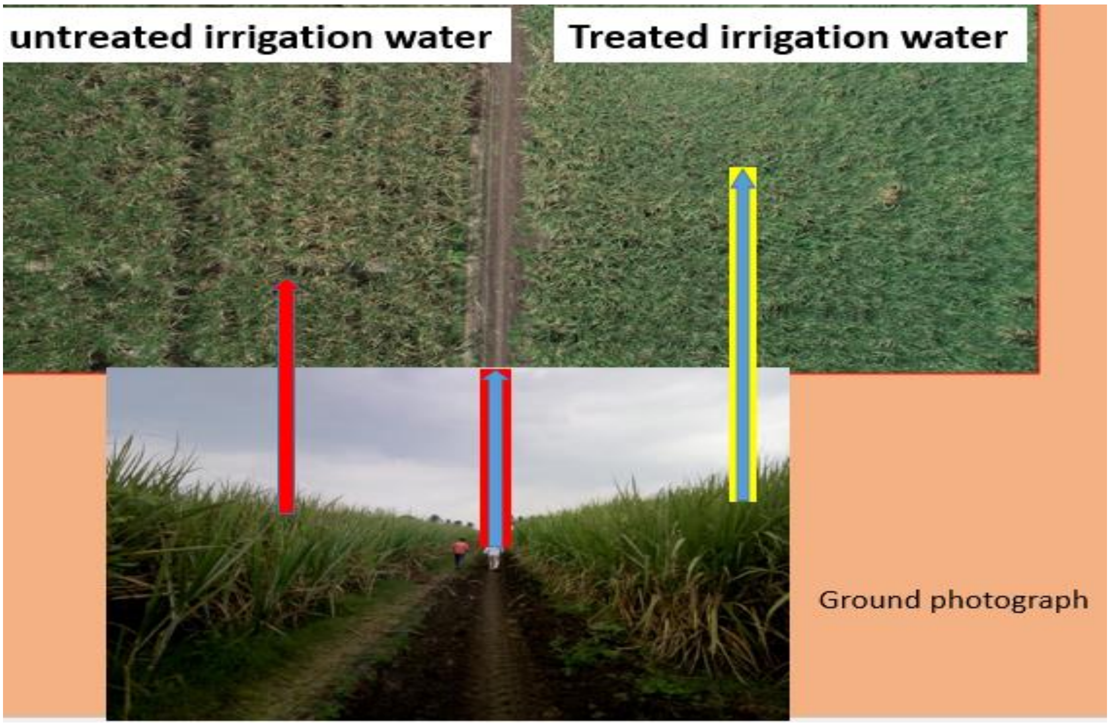

Figure 7 Drone image showing differences sugarcane growth by treated and untreated water from 15 ft).

10. Summary and Conclusions

It may be summarised that poor quality irrigation water is being used as supplementary or total water for crops in semi-arid and arid regions. The salt loaded to the soil ranges from 4400 to 16500 kg/acre/irrigation. It leads soil damage and crop yield. Device employing Electrolysis-electromagnetic approach was developed and tested in fields in terms of water quality, soil health and crop growth. The positive impacts of usage of this device in terms of cost of treatment, enhanced crop productivity and salt load. The cost recovery of the device from one season of Maize is about 75% in addition of environment, food security etc.

It may be concluded that

- The detrimental parameters for the crops found in the irrigation water were reduced to acceptable limits. The successful reduction percentage viz raw water - pH (1.57-5.88 %), EC 3.08- 10.08 %), ions (0.96 - 46 %).
- Treatment on irrigation water using the device employing the electrolysis and electromagnetic technology reduces EC (10.97 %), Na (0.96%), Ca (43.33%), Cl (34.78%) and HCO_3 (15%) of input and shows positive impact on soil health.
- Treated water reduce (15%) ions of reactive potentials and clustered crystals that pose problems.

- The use of treated water has increased the yield of about 17.25 % to 37 % for maize and sugarcane compared to untreated irrigation water.
- Low-quality irrigation water adversely effects on the irrigation system. Through study it is confirmed salt encrustation in delivery system lateral and drippers get clogged and reduce water use efficiency.
- Use of Low-quality irrigation water precipitate and deposit accumulation of salts Ca, Mg, Na and $CaCO_3$ in delivery systems. The continuous application makes the system redundant. Treated water resist the salt to deposited the inside micro irrigation system causes the increase of life of the delivery system and saves the cleaning consumable operational cost of the delivery system.
- 10% to 40 % of salt reduction in irrigation water improves nutrient uptake capacity of the soil and use of fertilizers.
- Aerial survey by drone camera will be very effective, economical and real time solution for identifying defective patches in the field and precision agriculture and flying height.

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