CHAPTER- 4

FIELD EXPERIMENTS

USING

TREATED OIL WELL EFFLUENT

INTRODUCTION

Industrial development in many countries is causing severe water pollution. Mismanagement in agriculture often induces secondary salinisation of soils and sources of irrigation water. With the industrialization and rapid urbanization, a stage is being reached when the limited inland water is progressively diminishing due to the ever increasing withdrawal of water for supply Time is approaching when it would be obligatory to move away wastewater from streams and rivers where it persists as pollutant and divert it to land where it acts as valuable resource [1]. Low rain fall and high aridity cause frequent scarcity of water in these regions of the world. The use of every drop of available water becomes imminent in these regions. The world prospectus indicate that quality of irrigation water tend to deteriorate so that it becomes necessary to utilize water of even poor quality for irrigation [2]. Water commonly classified as unsuitable for irrigation by conventional methods can often be used successfully to grow crops without hazardous long term consequences to crops or soils with the help of improved farming and management practices [3,4]. Several schemes were proposed to assess the suitability of effluent for irrigation. It depends up on the condition of use, crops to be irrigated, the soil conditions, climate, the irrigation method adopted and the management practices [4,5].

In many areas the availability of good quality water is often limited and farmers have to resort to the use of saline and sodic ground water for irrigation [6]. The response of the plants to the saline environment is interesting to people of many discipline. The development of crops with increased salt tolerance and the adoption of the new crops and water management strategies will further enhance and facilitate the use of saline water for irrigation and crop production, while keeping the soil salinity from becoming excessive [4.).

The vast agricultural water requirement in arid countries can be obtained from treated wastewater. To assess the suitability of a given effluent water for irrigation purpose, the tolerance limit of the plants to be irrigated with respect to the total salinity and the effect of each individual ions must be known.The other step in analyzing the suitability of effluent water for irrigation is by considering all possible effects on the soil and the effect of the soil parameters on the rate of salt accumulation and leaching [7].

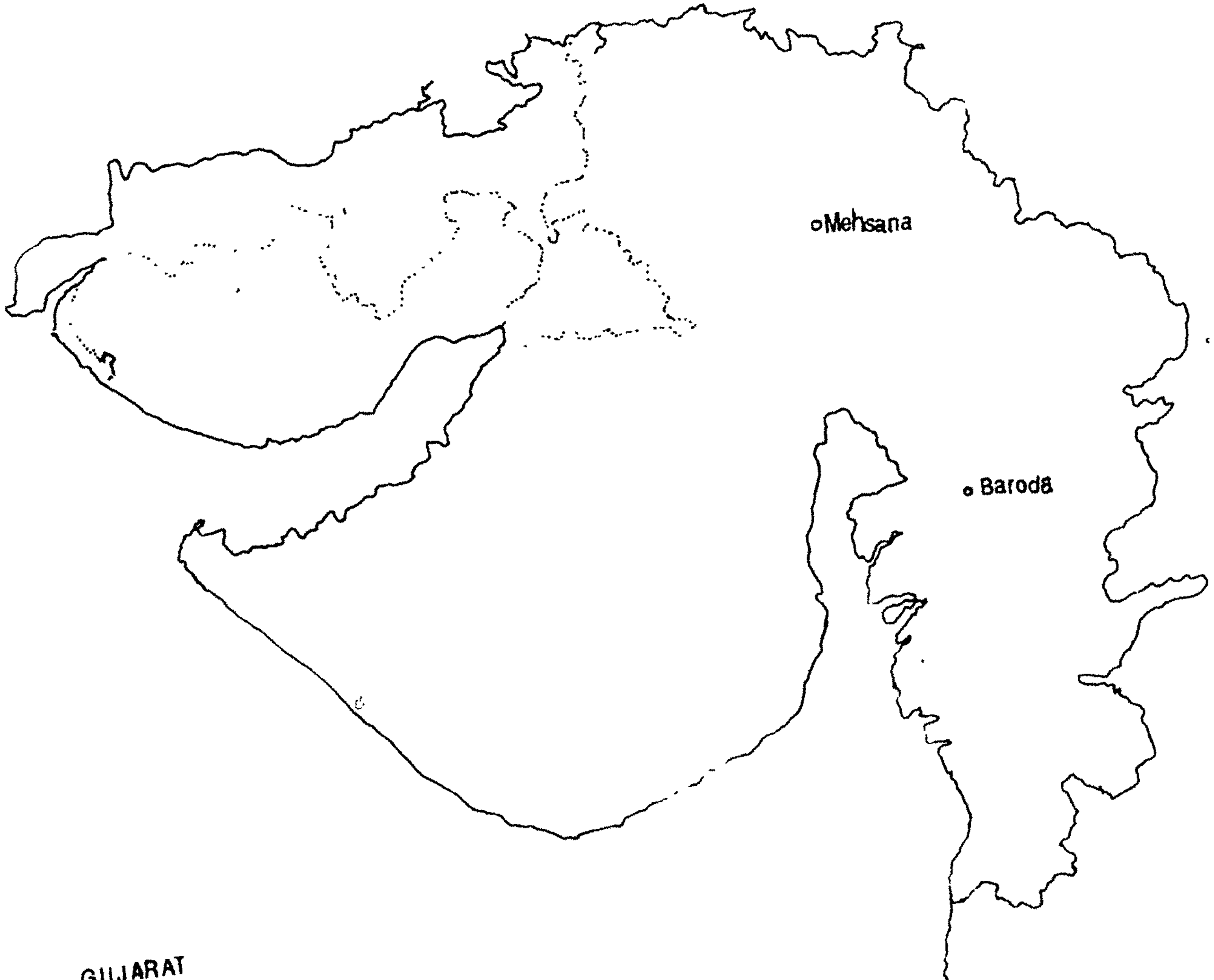
Saline and sodic waters are used for irrigation in many arid and semi arid regions of the world [8]. In regions of high aridity such as those of North Gujarat, Rajasthan, Uttar Pradesh of India the use of saline water for irrigation has become a common practice. Though the reports on the successful use of saline water for irrigation is limited, sufficient information is available to show that water with more salinity than conventional scheme of water classification can be used for irrigation. For example, in Russia cotton and alfalfa were grown with water containing TDS 12,500 mg/l (9]. It has been claimed that sea water can be used for irrigation [10]. Pear trees were irrigated with water containing 4000 mg/l TDS with out any reduction in yield [11]. Barley was grown in field plots with out any yield reduction with water of 20,000 mg/l salinity, but only after using ground water for seedling establishment [12]. There are some economic plants that can be grown satisfactorily using irrigation water containing 1% NaCl provided the substrate(soil) has high permeability [13].

Water capable of causing salinity and sodic hazards need specialized soil-water- crop management practices [14,15]. Little is known about the long term effect of saline water irrigation on building up of salinity and soil sodium saturation in the profile. It was reported that there is no adverse effect on production of corn grain and alfalfa, when they were irrigated with cooling tower water [16].

High concentration of salts prevents ready absorption of water and nutrients by plant root and impedes plant growth [1]. Accumulation of salt in soil increases the soil salinity which decreases the osmotic potential of the soil water. The osmotic and metric potential components together create a total potential against which the plants must work to absorb water [17]. Irrigation with saline water introduces salts in the soil and may impose a stress on growing crops that can lead to decrease in yield. This stress can be due to osmotic effect or specific ion toxicity which would adversely affect plants as well as the physico- chemical properties of the soils, namely poor permeability and aeration of soils [8].

Crop water requirement and irrigation water quality are two primary parameters that have to be considered in order to ensure proper water management for salinity control [18].Irrigation management consists of number of practices which when used together facilitate the efficient application of water for crop production. One of the most important management practices available for coping with the problems of the irrigation water and soil salinity is the irrigation interval [19]. Little experimental evidence exists to support the common recommendation that the irrigation interval should be decreased when saline water is used for irrigation [20]. From the point of view of agriculture it is therefore of utmost importance to know the various responses of plants to salinity and to understanding the nature of the damage caused by salinity.

The Mehsana region of North Gujarat, India, receives an average rain fall of 600 mm per annum mostly between July and September. Under the impact of developing



GUJARAT

agriculture, the ground water table has dropped from 8 meters to 75 meters [21]. The oil-well effluent taken from O N G C Mehsana project for this study was containing 9000 mg/l of TDS. This effluent and its different dilution with varying pH values were applied to the plants. The pollution control board rules do not allow this effluent to be released in to the streams and these are therefore being pumped back into the oil well strata. This practice interferes the yield of oil and also increases the proportion of water in oil emulsion. Out put of water from these plants is more than 5000m3 every day. So it is desired to utilize this effluen to increase the agricultural productivity and environment of Mehsana region. The soils in this region are extremely porous with excellent drainage profile.

EXPERIMENTAL PROCEDURE

A number of field trials were conducted to assess the specific conditions under which saline effluent can be used for irrigating farm crops and trees. The trials were undertaken at North Kadi, North Santhal and Shobhasan with alfalfa, Bajra, Jawar and Methi. Initially only ground water was used for growing of the seedlings till they are established. Treatments involving ground water and irrigation water with 2:1, 4:1 and undiluted effluent water(9000 mg/l TDS) were applied. In North Kadi field trials were conducted for two years for assessing the possibility of utilizing modified oil well effluent for raising fodder crop alfalfa. The results of these experiments on plant height, yield(fresh weight of each harvest cutting), changes in soil pH and conductivity are presented.(Table- 1, 2)

Soil pH is an important parameter as it determines the availability of nutrients to plants and often it has to be modified from time to time, to achieve sustained farm production. Since the growth of plants is known to affect the properties of soil namely pH, conductivity, buffering capacity etc., it was decided to monitor the above changes in the experimental plots of alfalfa at North Kadi. Table- 1shows pH values of different soils of plots of alfalfa at North Kadi. Treatment in these trials include irrigating with effluent water having different pH values.

One year old saplings of Casuarina equisetifolia (Saru), Eucalyptus hybrida (Nilgiri), Albizia lebbeck (Siras), Dalbergia sissoo (Shisham), Leucaena latisiliqua (Subabul), Azadirecta indica(Neem) were planted 25 feet apart in June 1990. In September 1990, when the seedlings were established, they were subjected to four treatments namely T1= bore water, T2= 75% water + 25% effluent, T3= 50% water + 50% effluent, T4= effluent water.

RESULTS AND DISCUSSION

The results establish a considerable capacity of North Kadi soils to handle salinity. The results of the field trials, with Sorghum and Bajra showed that at least during two years of field trial, the yield of these crops have not dropped due to salinity. The data on the heights of plants clearly indicate that there is no reduction in their height due to treatment (Table-3, 5). Moreover there was no visible symptoms of salt damage on the leaves. Neither the reduction in pH nor treatment with different concentrations of effluent caused any damage. The data on the fresh weight of the plants, show significant increase due to treatment.s However this trend is not reflected by data on the second and third harvests. Similarly fresh weights of harvested plants also showed no adverse effect of treatments.(Table- 4,6)

Details of experiments of response of alfalfa (*Medicago sativa* L.)to varying concentrations of ONGC oil well effluent of two pH values.

Location: Effluent Treatment Plant (ETP), North Kadi, Mehsana.

Year: 1991-'92 and 1992- '93

Temperature: Minimum 7°C and maximum 38°C

Cultivation: As per method prescribed by the Director of Research, Gujarat Agriculture University

Plot size: 20000 sq. ft., Individual-T. plot- 400 sq. ft.

Design: Latin Sq.

Number of treatments: 6 (six)

Number of replications: 5 (five)

Date of sowing: September 10, 1991

Seeding rate: 6 kg/20000 sq. feet

Fertilizer: 10 kg/ 20000 sq. ft., DAP as a basal dose

Irrigations: At an interval of 12- 14 days

Treatments: Given 4 times at an interval of 12- 14 days

T1= Control(pH 7.5) ; T2= 1: 4 (pH 7.5) ; T3= 1: 9 (pH 7.5);

T4= Control(pH 5.5) ; T5 = 1; 4(pH 5.5) ; T6= 1: 9 (pH 5.5)

* The first figure in the ratio indicate the proportion of effluent water, the second figure indicates the proportion of the bore water.

Influence of oil well effluent treatment on the pH of the alfalfa plot at North Kadi

Table-1

Treatments(pH)	Replication						F value
	1	2	3	4	5	6	
1	9.02	8.41	9.04	8.52	8.79	8.31	
2	8.81	8.51	8.63	8.51	9.38	8.09	
3	9.11	8.81	8.69	8.68	8.52	9 9.0	
4	8.62	8.86	8.9 8.	9 8.9	8 85	8.84	0.38*
5	8.73	9.20.	8.62	9.4	8.4	9.02	0.65*
6	8.5	9.29	8.93	9.27	8.38	8.52	

*Required F value at 0.05= 2.6

Influence of oil well effluent treatment on soil solution conductivity (mhosX10cm) of alfalfa plot at North Kadi

Table-2

Treatments(pH)	Replication						F value
	1	2	3	4	5	6	
1	3.0	2.1	3.6	3.5	3.7	2.3	
2	3.7	1.7	3.6	3.6	3.6	2.4	
3	2.4	2.1	2.5	2.8	2.4	2.9	
4	1.6	2.1	2.4.	2.6	3.3	2.9	3.79*
5	2.0	2.4.	2.9	3.0	2.2	4.5	1.12*
6	1.4	2.5	1.9	1.7	1.5	0.9	

*Required F value at 0.05= 2.6

Details of experiments of response of Sorghum (Jowar) (*Sorghum bicolor* L.) to varying concentrations of ONGC oil well effluent for two pH values.

Location: Effluent Treatment Plant (ETP), North Santhal, Mehsana.

Year: 1991-'92

Temperature: Minimum 7°C and maximum 38°C

Cultivation: As per method prescribed by the Director of Research, Gujarat Agriculture Univversity

Plot size: 20000 sq. ft., Individual-T. plot- 400 sq. ft.

Design: Latin Sq.

Number of treatments: 6 (six)

Number of replications: 6 (six)

Date of sowing: May 4, 1991

Seeding rate: 8 kg/ 20000 sq. feet

Fertilizer: 15 kg/ 20000 sq. ft., DAP as a basal dose

Irrigations: At an interval of 5- 7 days

Treatments: At an interval of 15 days

T1= Control(pH 7.5) ; T2= 1: 4 (pH 7.5) ; T3= 1: 9 (pH 7.5);

T4= Control(pH 5.5) ; T5 = 1; 4(pH 5.5) ; T6= 1: 9 (pH 5.5)

* The first figure in the ratio indicate the proportion of effluent water, the second figure indicates the proportion of the bore water.

Influence of oil well effluent treatment on the Height (cm) of Sorghum (*sorghum bicolor*)

Table-3

Treatments(pH)	Replication						F value
	1	2	3	4	5	6	
1	60.0	60.5	63.0	53.0	55.0	58.0	
2	62.5	71.0	69.0	62.0	61.5	64.0	
3	62.0	69.0	71.0	68.0	60.0	52.0	
4	63.5	62.0	65.0	71.0	73.0	72.0	2.94*
5	72.0	73.0.	61.0	63.0	64.5	68.0	0.21*
6	61.0	57.0	56.0	64.0	62.0	65.0	

*Required F value at 0.05= 2.6

Influence of oil well effluent treatment on the Fresh weight (kg) of Sorghum (*Sorghum bicolor*)

Table-4

Treatments(pH)	Replication						F value
	1	2	3	4	5	6	
1	9.50	9.90	9.30	9.10	8.50	10.5	
2	11.0	12.5	12.0	10.5	9.50	10.5	
3	12.5	11.0	13.0	9.50	10.5	12.5	
4	8.50	12.5	9.00	12.0	11.5	12.0	2.23*
5	13.0	15.5.	10.5	8.00	10.5	13.5	1.58*
6	10.5	11.5	12.0	13.0	12.0	12.5	

*Required F value at 0.05= 2.6

Details of experiments on the influence of varying concentrations of oil well effluents on the growth and weight of bajra (*Pennisetum typhoideum*) at two pH values.

Location: Shobhasan, Mehsana.

Year: 1991-'92

Temperature: Minimum 7°C and maximum 38°C

Cultivation: As per method prescribed by the Director of Research, Gujarat Agriculture university.

Plot size: 5000 sq. ft., Individual-T. plot- 100 sq. ft.

Design: Randomised block design.

Number of treatments: 6 (six)

Number of replications: 6 (six)

Date of sowing: May 1, 1991.

Seeding rate: 5 kg/5000 sq. feet

Fertilizer: 15 kg/ 5000 sq. ft., DAP as a basal dose

Irrigations: At an interval of 5- 7 days

Treatments: One treatment at the end of 6 weeks after sowing

T1= Control(pH 7.5) ; T2= 1: 4 (pH 7.5) ; T3= 1: 9 (pH 7.5);

T4= Control(pH 5.5) ; T5 = 1; 4(pH 5.5) ; T6= 1: 9 (pH 5.5)

* The first figure in the ratio indicate the proportion of effluent water, the second figure indicates the proportion of the bore water.

Influence of oil well effluent treatment on the Height (cm) of Bajra

(*Pennisetum typhoideum*)

Table-5

Treatments(pH)	Replication						F value
	1	2	3	4	5	6	
1	20.0	15.0	21.0	31.0	20.0	21.0	
2	29.0	23.0	21.0	21.0	25.0	19.0	
3	25.0	23.0	21.0	22.0	19.0	21.0	
4	24.0	23.0	26.0	20.0	31.0	26.0	0.73*
5	21.0	20.0.	30.0	22.0	24.0	24.0	0.47*
6	23.0	24.0	26.0	20.0	21.0	22.0	

*Required F value at 0.05= 2.6

Influence of oil well effluent treatment on the Fresh weight (kg) of Bajra

(*Pennisetum typhoideum*)

Table-6

Treatments(pH)	Replication						F value
	1	2	3	4	5	6	
1	19.0	18.0	21.0	18.0	17.5	20.5	
2	19.0	18.5	20.0	21.5	19.5	19.0	
3	17.5	23.5	24.0	19.5	20.0	18.0	
4	19.5	19.5	20.5	21.5	19.5	18.5	0.61*
5	18.5	23.5.	17.0	18.5	18.5	21.0	1.11*
6	18.5	23.0	16.5	15.5	18.5	19.5	

*Required F value at 0.05= 2.

Plate I

A general view of the plantation

Albizia lebbeck (L.) Bth. [Kalosaras] MIMOSACEAE

Plate II

Azadirachta indica A. Juss. [Limdo] MELIACEAE

Cassia siamea Lam. CAESALPINIACEAE

Plate III

Casuarina equisetifolia L. [Sharu] CASUARINACEAE

Dalbergia sissoo Roxb. [Motosisam] FABACEAE

Plate IV

Eucalyptus globulus Labill. [Nilgiri] MYRTACEAE

Leucaena latisiliqua (L.) Gills [Pardesi baval] MIMOSACEAE

Table(1) shows the different pH of soil extracts of plot in the field. No significant difference in pH due to treatments is noticeable. It may also be concluded that the treatments have not been able to overcome the buffering capacity of the soil. The conductivity of soil solution (1:10) at the end of 102 days of the experiments showed significant change due to treatments. In each of the plots wit lowered pH, the conductivity of the soil solution was lower than that of the soil solution of the corresponding treatments with higher pH. The statistical analysis , however shows no significance in replications. The findings suggest that there is a leaching effect, with increased irrigation and that effect is stronger with lower pH of irrigating waters. It is possible that such leaching effect is restricted to the surface and root zones and that lower horizons are being enriched in materials leached from upper zones.

Trees grown for one and a half years using undiluted treated effluent, clearly indicate the possibility of using Mehsana oil field effluent to support their growth (Plate nos. 1- 4). Initially only ground water was used for growing the saplings, till they were established. After three months the treatments were started. Within six months it was evident that tree growth was not limited by TDS of the irrigated water, but by the frequency of irrigation. The treatments were only limited to 9000 mg/L TDS and the frequency of irrigation was increased from once a week to once in every four days. It is felt that under more moist regime the adsorption of sodium in the exchange complex will be less and the continuous hard pan formation is considerably reduced as the distance between the trees are increased. It is also noticed that when these soils dry out, the upper layer of the soil formed a hard pan. However the hardness of the pan was very slight and the soil crumbled easily while handling. In the light of these observations, it was suggested that the trees be grown between 50 and 100 feet apart in frequent irrigation regimes.

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