GROUNDWATER QUALITY AND SUBSEQUENT EFFECT ON SOILS IN TALUKA TANDO ADAM DISTRICT SANGHAR (SINDH)

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ABSTRACT: *The groundwater quality and subsequent effect on soils was evaluated during 2012-13 in taluka Tando Adam, District Sanghar (Sindh). The water and soil samples were collected and subjected to determine for various physico-chemical properties and accordingly the results were formulated and compared with FAO standard values. The groundwater and soil EC, pH, HCO_3^-, CO_3^-, Na^{2+}, Ca^{2+}, $SO4^{2-}$, SAR and TDS showed significant ($P<0.05$) location to location disparity and inconsistency. Water EC ranged between 1164-2293.25 µS cm^{-1} (FAO: 0-3000 µS cm^{-1}), pH 7.475-8.075 (FAO: 6.5-8.4), HCO_3^- 2.1625-2.35 meq L^{-1} (FAO: 0-10), CO_3^- 0.1125-0.1625 meq L^{-1} (FAO:0-1 meq L^{-1}), Na^{2+} 11-14 meq L^{-1} (FAO:0-40 meq L^{-1}), Ca^{2+} 5-8 meq L^{-1} (FAO:0-20 meq L^{-1}), $SO4^{2-}$ 9-11 meq L^{-1} (FAO:0-20 meq L^{-1}), SAR 6-11 (FAO: 0-15), and TDS 837-1725. The physico-chemical properties in water were within FAO permissible limits; and groundwater was suitable for human consumption as well as for agriculture use. The soil physico-chemical analysis (sample-I) indicated that soil EC ranged between 1221-2434µS cm^{-1}, pH 7.8-8.3, HCO_3^- 1.675-2.5875 meq L^{-1}, CO_3^- 0, Na^{2+} 11.4125-14 meq L^{-1}, Ca^{2+} 6-7 meq L^{-1}, RSC 0, TDS 837-1902. The soil sample-II results indicated that all the determined values were within the permissible limits of FAO.*

Keywords: Groundwater quality, soil physico-chemical properties, crop productivity.

INTRODUCTION

Pakistan is experiencing severe shortage of water and faces nearly insurmountable challenges in meeting the demand of its growing population, which was 140 million in 2000, and is projected to double by the year 2025 [6]. Pakistan being once water surplus country due to huge water resources of Indus River system is now water deficit. In 1947, water availability per capita was about 5000 cubic meter; this will decrease to about 1200 cubic meter per capita by the year 2025 [2]. The present water resources are inadequate to meet the irrigation and other water requirements, and there are no prospects of augmenting the water availability in the near future [21] Due to low rains, the water situation is getting worse and currently the Pakistan is facing 36% water shortage. The shortfall in rains is about 70% that has resulted in severe shortage for irrigation as well as food production and electricity generation. The immediate water shortage crisis in Pakistan is severe, and experts maintain that the long-term forecast is bleaker [22]. This indicates that the country is well short of the water requirements for routine agriculture. Hence, it becomes indispensable to plan strategies with concrete measures in order to properly manage irrigation water at all levels [26].

Groundwater is about 20 percent of the world resources of fresh water and used in large amount for industry, irrigation and domestic activity. However, groundwater quality in most of the third world countries including the subcontinent is deteriorating fast [16]. The major problems identified were the higher values of turbidity, nitrate, TDS and lead [19]. Water quality both for human use as well as for agriculture has become a serious problem in Pakistan [1]. The 30% of the tube wells of Indus Basin are pumping water useful for drinking and agriculture purposes, while about 70% of these tube wells are pumping saline water [6].

Analysis of groundwater quality is based on the careful measurement of certain related parameters such as pH, EC, Turbidity, colour, taste and odour, while the hardness of water is resulted by excessiveness of sodium, potassium, chloride, sulphate, nitrate, phosphate and TDS, Lead, Arsenic, Iron, fluoride, chromium, manganese, Molybdenum, nickel, Aluminum and selenium [3]. The WHO's rating for groundwater quality is based on TDS level. Excellent (<300 mg/1), the water with >300mg/L is termed as excellent quality water, while water having 300-600 mg/L is termed as good quality. Similarly, water having TDS values between 600-900 mg/L is fair and that with 900-1200 mg/L is poor. The water having TDS >1200 mg/L is unacceptable. Water with extremely low TDS levels may also be unacceptable because of its flat insipid taste [18].

Healthy soil provides a number of vital functions including the ability to store water and nutrients, regulate flow of water, and neutralize pollutants [11]. The groundwater of medium to high SAR reduces aggregate stability, increases the bulk density of both the surface crust and underlying soil, and reduces the final infiltration rate[8]. Inspite of productive soils, suitable climate, irrigation and hardworking farming communities, yields are far lower than those of developed countries. Apart from a variety of other reasons for low crop productivities, deteriorating quality of groundwater has adverse effects on soil structure and hence reduced soil fertility [5]. Groundwater quality which varied EC from 443–755 µS cm^{-1}, TOC (0.226–9.284 mg l^{-1}), UV absorbance (0.0–0.118 cm^{-1}), colour (0.0–119 CU), COD (9.0–113 mg l^{-1}) and MPN (0.0–93x101/100 mL) in the deeper hand pumps; while in case of shallower hand pumps conductivity (441–1609 µS cm^{-1}), TOC (0.015–68.82 mg l^{-1}), UV absorbance (0.0–1.094 cm^{-1}), colour (4.0–560 CU), COD (9.72–163 mg l^{-1}) and MPN (0.0–15x102/100 mL) [7]. The groundwater cannot be classified a healthy fresh water stream in most of the areas around River Krishni India [7]. Reproductive growth of the plants clearly reflects the quality of groundwater irrigating the crops [12]. The groundwater quality in the canal command area of Phuleli canal of Hyderabad city of Sindh province [25]. In ground water of canal command area, the higher EC (4.88 dS m^{-1}), HCO_3^- (5.11 meq l^{-1}), Cl^- (23.66 meq l^{-1}), $Ca^{2+}+Mg^{2+}$ (15.9 meq l^{-1}),

Na^+ (32.38 meq l^{-1}) and SAR (11.48) were noted near downstream during winter, while, (SO_4^{2-}) was higher during autumn season, however RSC was found absent.

In view of the facts stated above, the study was carried out during 2012-13 on the groundwater quality determination and subsequent effect on soils in taluka Tando Adam, District Sanghar (Sindh).

MATERIALS AND METHODS

1. Area of Study:

The study was carried out in Taluka Tando Adam, District Sanghar; lies in middle of Sindh; it is dry sub-tropical region. The soil texture of Tando Adam is alluvial, and is composed of light loose clay, mixed with fine sand. Banana, Sugarcane and cotton are the major cash crops and wheat is also major crop producing staple food.

2. Collection of Water Samples:

The survey and testing of water quality was carried out in Taluka Tando Adam, District Sanghar, Sindh, Pakistan. The area was divided in four parts. Eight ground water samples were collected from each part. A one page detailed history questionnaire was filled before collecting samples from proposed location and there were 32 samples.

3. Sampling Procedure:

Water samples were collected in one liter plastic bottles according to standard methods after at least ten (10) minutes of Tube well operations to get representative sample of groundwater.

Before collecting the samples, the bottles were washed properly and rinsed thoroughly with distilled water so as to remove any contamination. The depth of groundwater level and location of the tube well was properly marked on the map. X, Y coordinates of well was taken with the help of GPS. Collected water samples were analysed for Physical and Aesthetic Parameters i.e pH, Electrical Conductivity (EC), Total Dissolved Salts (TDS) and Chemical Parameters i.e Carbonbate (CO_3), Bicarbonate (HCO_3), Calcium (Ca) + Magnesium (Mg), Sodium (Na), Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), Sulphate (SO_4). The pH of soil water extracts and water samples was determined by portable pH multimeter (HAQ Model USA) after calibration at buffers of pH 4.0, pH 7.0 and pH 9.0. Electrical conductivity (EC) was determined with the help of portable conductivity multimeter (HAQ Model USA) using the standard reference solution which at 25^{o}C has a conductivity of 1413 uS/cm. TDS was determined with the help of portable conductivity multimeter (HAQ Model USA)

4. Chemical Parameters of saturation extract and water samples:

4.1. Soluble Calcium plus Magnesium of saturation extract and water samples:

By titrating the saturation extract with 0.01N EDTA in the presence of NH_4Cl+NH_4OH buffer solution and Eriochrome Black T indicator. The color changed from wine red to blue (Method 7, p.94).

4.2. Sodium of saturation extracts and water samples:

Sodium was determined with the help of Flame photometer-Jenway UK Model No. PFP-7. (Method 10a, p.96).

4.3. Carbonate and bicarbonate:

By Titrating the saturation extract with 0.1N H_2SO_4 using phenolphthalein and methyl orange indicators, respectively. Chlorides and pinkish yellow were the end points for CO_3 and HCO_3 respectively (method 12, p. 98).

4.4. Sodium absorption ratio (SAR):

The following formula for Sodium absorption ratio (SAR) was adopted (Rowell, 1994 and Qureshi and Barret-Lennard, 1998)

$$SAR = \frac{Na}{(Ca+Mg/2)^{1/2}}$$

4.5. Residual sodium carbonate:

Residual sodium carbonate was calculated. (Rowell, 1994)

Residual sodium carbonate

(RSC) = (CO_3^{-2} + HCO_3^-) - (Ca^{+2} + $Mg^{+2)}$

4.6. Discharge of Tube Wells:

Discharge of Tube wells was calculated by using both volumetric and Trajectory Methods.

4.7. Soil sampling and analysis

Two composite soil samples were taken at soil depth of 0-20 cm with the help of auger from randomly selected locations along the slope. The samples were sent to the laboratories of Agriculture Chemistry (Soils) Section, Agriculture Research Institute, Tandojam and Soil Science Department, Sindh Agriculture University Tandojam for detailed analysis.

4.8. Soil water extract:

Soil water extract of ratios of 1:2 was adopted (method 3, p. 88 and Rowell, 1994).

4.9. Statistical analysis:

The data thus collected was analyzed using analysis of variance and multiple range tests (Steel and Torrie, 1980).

RESULTS

Physico-chemical properties of water

The EC, pH, HCO_3^-, CO_3^-, Na^{2+}, Ca^{2+}, $SO4^{2-}$, SAR and TDS varied significantly ($P<0.05$) between different zones of the study area and the data (Table-1) showed that EC of the water samples collected from Berani, Usman Shah Huri, Tando Adam and Oderolal area was 2087, 1967.25, 2293.25 and 1164 µS cm^{-1} (FAO: 0-3000 µS cm^{-1}), pH value 7.25, 7.9125, 8.075 and 7.475 (FAO: 6.5-8.4), HCO_3^- 2.30, 2.35, 2.10 and 2.1625 meq L^{-1} (FAO: 0-10), CO_3^- 0.1125, 0.1625, 0.1125 and 0.1500 meq L^{-1} (FAO:0-1 meq L^{-1}), Na^{2+} 14, 13, 12 and 11 meq L^{-1} (0-40 meq L^{-1}), Ca^{2+} 8, 7, 9 and 5 meq L^{-1} (FAO:0-20 meq L^{-1}), $SO4^{2-}$ 9, 9, 9 and 11 meq L^{-1} (FAO:0-20 meq L^{-1}), SAR 7, 7, 6 and 11 (FAO: 0-15), respectively; while the TDS in water samples were 1427, 1520, 1725 and 837, respectively.

The EC and pH were maximum in Tando Adam water samples and minimum in Oderolal area samples; while HCO_3^- and CO_3^- were higher in Usman Shah Huri and lower in Tando Adam. Higher values for Na^{2+} were determined in Berani, Ca^{2+} and TDS in Tando Adam; while $SO4^{2-}$ in Oderolal water samples. Regardless the considerable variation in EC, pH, HCO_3^-, CO_3^-, Na^{2+}, Ca^{2+}, $SO4^{2-}$, SAR and TDS in water samples from different zones (Berani, Usman Shah Huri, Tando Adam and Oderolal), the determined values for these physico-chemical characteristics in water were within the permissible limits of FAO; and the ground water in these areas was suitable for human consumption as well as for agriculture use.

Physico-chemical properties of soil (Sample-I)

The soil samples initially collected (sample-I) were subjected to determine for EC, pH, HCO_3^-, CO_3^-, Na^{2+}, Ca^{2+}, $SO4^{2-}$, SAR and TDS and showed significant ($P<0.05$) variation in these soil properties between different zones of the study area. the data in Table-2 indicated that the soil EC in Berani, Usman Shah Huri, Tando Adam and Oderolal area zones was 2218, 1989, 2434 and 1221 µS cm^{-1} (FAO: 0-3000 µS cm^{-1}), pH value 8.1, 8.3, 8.3 and 7.8 (FAO: 6.5-8.4), HCO_3^- 2.0125, 1.725, 1.675 and 2.5875 meq L^{-1} (FAO: 0-10), CO_3^- 0, 0, 0 and 0 meq L^{-1} (FAO:0-1 meq L^{-1}), Na^{2+} 13, 12, 11.4125 and 14 meq L^{-1} (0-40 meq L^{-1}), Ca^{2+} 7, 6, 6 and 7 meq L^{-1} (FAO:0-20 meq L^{-1}), RSC 0, 0, 0 and 0, respectively; while the TDS in soil samples were 1571, 1638, 1902 and 837, respectively.

The results further showed that the higher soil EC and pH as well as higher TDS were determined in Tando Adam soil samples and lower in soil samples collected from Oderolal area; while HCO_3^-, Na^{2+} and Ca^{2+} were higher in Oderolal area soil samples and lower and lower in soil samples collected from Tando Adam.. Although, there was marked disparity in characteristics like EC, pH, HCO_3^-, CO_3^-, Na^{2+}, Ca^{2+}, $SO4^{2-}$, SAR and TDS in soil samples collected from Berani, Usman Shah Huri, Tando Adam and Oderolal area, but the determined values for these physico-chemical properties in soil were well below the maximum limits referred by FAO. Hence, it could be considered that the soils of the Berani, Usman Shah Huri, Tando Adam and Oderolal area are normally suitable for crop production; because the determined values for not a single of the soil physico-chemical properties referred to be adverse for the agriculture production.

Physico-chemical properties of soil (Sample-II)

The second sample of the soil (sample-II) was collected and also examined for EC, pH, HCO_3^-, CO_3^-, Na^{2+}, Ca^{2+}, $SO4^{2-}$, SAR, TDS and suggested significant ($P<0.05$) difference in the physico-chemical soil properties between different zones. The data in Table-3 showed that the soil EC in Berani, Usman Shah Huri, Tando Adam and Oderolal area zones was 2268, 2042, 2555 and 1289 µS cm^{-1} (FAO: 0-3000 µS cm^{-1}), pH value 8.7, 8.4, 8.4 and 8.0 (FAO: 6.5-8.4), HCO_3^- 1.7375, 1.675, 1.5375 and 1.85 meq L^{-1} (FAO: 0-10), CO_3^- 0, 0, 0 and 0 meq L^{-1} (FAO:0-1 meq L^{-1}), Na^{2+} 13, 13, 12 and 16 meq L^{-1} (0-40 meq L^{-1}), Ca^{2+} 6, 6, 6 and 7 meq L^{-1} (FAO:0-20 meq L^{-1}), RSC 0, 0, 0 and 0, respectively; while the TDS in soil samples were 1605, 1713, 1001 and 952, respectively.

The results further showed that the higher soil EC was highest in Tando Adam and lowest in Oderolal area; pH was higher in Berani and lowest in Oderolal area; HCO_3^-, Na^{2+} and Ca^{2+} were higher in Oderolal area soil samples and lower in soil samples collected from Tando Adam. Although, there was noticeable inconsistency in soil properties for EC, pH, HCO_3^-, CO_3^-, Na^{2+}, Ca^{2+}, $SO4^{2-}$, SAR and TDS in soil samples collected from Berani, Usman Shah Huri, Tando Adam and Oderolal area, but the determined values for these physico-chemical properties in soil (sample-II) were well below the maximum limits referred by FAO with the exception of pH value. The soil pH in Berani zone was determined to be higher than the permissible limits of FAO; while in Usman Shah Huri and Tando Adam the soil pH was at par with the FAO limits; while the soils of Tando Adam were within the permissible limits for pH value. It was observed that the soil pH of the Berani, Usman Shah Huri and Tando Adam areas was either at par or crossing the maximum FAO limits and necessary steps are needed to be taken to keep the soil pH below the permissible limits of FAO. However, except the soils of Berani, the soils of all other zones were determined to be yet suitable for agriculture.

DISCUSSION

The quality of groundwater in Pakistan and particularly most areas of Sindh is deteriorating fast due to varied certain and uncertain causes. The study embodied in this thesis aimed at determination of groundwater samples for pH, Electrical Conductivity (EC), Turbidity, Colour, Taste, Odor, Alkalinity as $CaCO_3$, Bicarbonate (HCO_3), Carbonate (CO_3), Calcium (Ca), Sodium (Na), Total Dissolved Solids (TDS) in Tehsil Tando Adam, District sanghar (Sindh). Analysis of groundwater quality is based on the careful measurement of certain related parameters such as pH, EC, Turbidity, colour, taste and odour, while the hardness of water is resulted by excessiveness of sodium, potassium, chloride, sulphate, nitrate, phosphate and TDS, Lead, Arsenic, Iron, fluoride, chromium, manganese, Molybdenum, nickel, Aluminum and selenium [3].

The present study showed that determined values for physico-chemical characteristics in water were within the permissible limits of FAO; and the ground water in these areas was suitable for human consumption as well as for agriculture use. The WHO suggested 6.5-8.5 pH range as suitability of water for agriculture use and human consumption; while EC is a measure of the ability of water to carry an electric current, and turbidity which is caused by the presence of clay, silt colloidal organic particles and other microscopic organisms. According to a report (PCRWR, 2007), the WHO's rating for groundwater quality is based on TDS level. Excellent (<300 mg/1), the water with >300mg/L is termed as excellent quality water, while water having 300-600 mg/L is termed as good quality. Similarly, water having TDS values between 600-900 mg/L is fair and that with 900-1200 mg/L is poor. The water having TDS >1200 mg/L is unacceptable. Water with extremely low TDS levels may also be unacceptable because of its flat, insipid taste. In view of the above WHO standards, the groundwater in Taluka Tando Adam of Sanghar district is poor in quality and its consumption without treatment is harmful for human health.

The soil physico-chemical analysis (sample-I) indicated that soil EC ranged between 1221-2434µS cm^{-1}, pH 7.8-8.3, HCO_3^- 1.675-2.5875 meq L^{-1}, CO_3^- 0, Na^{2+} 11.4125-14 meq L^{-1}, Ca^{2+} 6-7 meq L^{-1}, RSC 0, TDS 837-1902. The soil sample-II results indicated that all the determined values were within the permissible limits of FAO. Sample-II soil determination indicated that soil EC ranged between 1289-2555, pH 8.00-8.7, HCO_3^- 1.5375-1.85 meq L^{-1}, CO_3^- 0, Na^{2+} 12-16 meq L^{-1}, Ca^{2+} 6-7 meq L^{-1}, RSC 0 and TDS 952-1605. Zonal disparity and inconsistency in soil properties was observed but mostly were within the permissible limits of

FAO with the exception of soil pH in Berani zone, that was higher than the permissible limits of FAO; while in Usman Shah Huri and Tando Adam the soil pH was at par with the FAO limits; while the soils of Oderolal were within the permissible limits for pH value. These results are in agreement with those of Kaushik *et al*., (2002) who found that pH, EC, turbidity, TDS, alkalinity, total hardness, calcium, magnesium, sodium, potassium, chloride, nitrate, phosphate, sulfate and fluoride was fit for consumption. Latha *et al*., (2002) reported that in India (Tamil Nadu province), electrical conductivity (EC) of water used for crop irrigation was in the range of 0.45-4.50, 2.27-9.95 and 0.2-2.7 dS m^{-1} at three sites, respectively [17]. The groundwater samples and showed the values of total dissolved solids (86-1165 mg l^{-1}), iron (0.6-4.1 mg l^{-1}), nitrates (6.3-17.2 mg l^{-1}), sulfates (4.9-32.5 mg l^{-1}), chlorides (110-825 mg l^{-1}), calcium (60.0-185.3 mg l^{-1}), magnesium (33.2-140.0 mg l^{-1}), biochemical oxygen demand (6.2-22.0 mg l^{-1}) and chemical oxygen demand (18-38.5 mg l^{-1}) in all the selected water samples [27]. The EC of groundwater in Haryana (India) found to be 63.4% with EC values <4 dS m^{-1} and rest of the samples had EC values >4 dS m^{-1} which falls either in saline or high sodium absorption ratio saline categories. The maximum samples in saline (22.76%) category followed by marginally saline (21.27%). Good quality category recorded 15.67% samples and high SAR saline category accounted for 10.45% samples.

The percent samples in sodic classes were 2.99, 8.21 and 18.66% in marginally alkali, alkali and high alkali classes, respectively. The concentration of Na^+, Ca^{+2} and Mg^{+2} ions generally increased with increase in EC of the water samples. Chlorides and HCO_3^- were found in appreciable quantities, whereas CO_3^- was in traces. It is also very important to stress the role of human activities in the irrigation water quality. High values of ammonium and phosphates have been originating from domestic water and sewage [20]. The groundwater from some sampling sites is within permissible limits (WHO) [16]. The groundwater quality in the canal command area of Phuleli canal of Hyderabad city of Sindh province. In ground water of canal command area, the higher EC (4.88 dS m^{-1}), HCO_3^- (5.11 meq l^{-1}), Cl^- (23.66 meq l^{-1}), Ca^{2+}+Mg^{2+} (15.9 meq l^{-1}), Na^+ (32.38 meq l^{-1}) and SAR (11.48) were noted near downstream during winter, while, (SO_4^{2-}) was higher during autumn season, however RSC was found absent [25].

The present study further showed that the effect of increased soil EC and pH on the production was obvious and highest banana production was observed in Usman Shah Huri zone and lowest banana production was recorded in Berani zone of the study area. Higher banana production in Usman Shah Huri zone was mainly associated with lower soil EC and pH value, because recorded pH of Berani region was higher than the FAO permissible limits, and soil EC was also higher than Usman Shah Huri, Tando Adam and Oderolal area. The findings of the research are in accordance with those of Bajwa *et al* (1992) who concluded that under the cotton-wheat rotation, irrigation waters with high RSC values decreased the crop yields considerably more than irrigation waters with low RSC and high SAR values. The decrements in the yields of both wheat and cotton crops were almost similar under increasing levels of RSC in irrigation water. The impact low quality water on agricultural soils and concluded that the adverse impact on agricultural soils is mainly due to the presence of high nutrient contents (Nitrogen and Phosphorus), high total dissolved solids and other constituents such as heavy metals, which are added to the soil over time. Wastewater can also contain salts that may accumulate in the root zone with possible harmful impacts on soil health and crop yields [4]. The leaching of these salts below the root zone may cause soil and groundwater pollution. The water used for growing crops in Jordan was non-potable because most of the physical and chemical parameters examined exceed the permissible limits. Some sites were not suitable for irrigation because the conductivity was high and in addition had increased concentrations of chloride, bicarbonate, and nitrate. Few sites were characterized as the most polluted [1]. Gangyly *et al*., (2003) reported that a very low level of awareness in India was noticed among majority (51.50%) of farmers about contamination of groundwater with arsenic and other elements causing hardness of water not known to the majority

Table-1: Physico-chemical properties of water samples collected from different zones of district Sanghar, Sindh

Parameters	SE	LSD 0.05	Zones				FAO permissible limits
			Berani	Usman Shah Huri	Tando Adam	Oderolal	
EC (μS cm^{-1})	180.81	376.00	2087	1967.25	2293.25	1164	0-3000
pH	0.1191	0.2477	7.725	7.9125	8.075	7.475	6.5-8.4
HCO_3^- (meq L^{-1})	0.1526	0.3174	2.3	2.35	2.1	2.1625	0-10
CO_3^- (meq L^{-1})	0.0425	0.0883	0.1125	0.1625	0.1125	0.15	0-1
Na^{2+} (meq L^{-1})	0.8983	18,681	14	13	12	11	0-40
Ca^{2+} (meq L^{-1})	0.5625	1.1697	8	7	9	5	0-20
$SO4^{2-}$ (meq L^{-1})	0.6051	1.2583	9	9	9	11	0-20
SAR	0.4213	0.876	7	7	6	11	0-15
TDS	131.85	274.19	1427	1520	1725	837	--

Table-2: Physico-chemical properties of soils (Sample-I) collected from different zones of district Sanghar, Sindh

Parameters	SE	LSD 0.05	Zones				FAO permissible limits
			Berani	Usman Shah Huri	Tando Adam	Oderolal	
EC (µS cm^{-1})	143.07	297.53	2218	1989	2434	1221	0-3000
pH	0.1149	0.239	8.1	8.3	8.3	7.8	6.5-8.4
HCO_3^- (meq L^{-1})	0.316	0.6571	2.0125	1.725	1.675	2.5875	0-10
CO_3^- (meq L^{-1})	0	0	0	0	0	0	0-1
Na^{2+} (meq L^{-1})	0.5459	1.1354	13	12	11.4125	14	0-40
Ca^{2+} (meq L^{-1})	0.2139	0.4449	7	6	6	7	0-20
RSC	0	0	0	0	0	0	--
TDS	136.25	283.34	1571	1638	1902	837	--

Table-3: Physico-chemical properties of soils (Sample-II) collected from different zones of taluka Tando Adam District Sanghar, Sindh

Parameters	SE	LSD 0.05	Zones				FAO permissible limits
			Berani	Usman Shah Huri	Tando Adam	Oderolal	
EC (µS cm^{-1})	191.64	398.53	2268	2042	2555	1289	0-3000
pH	0.1329	0.2764	8.7	8.4	8.4	8.0	6.5-8.4
HCO_3^- (meq L^{-1})	0.1214	0.2524	1.7375	1.675	1.5375	1.85	0-10
CO_3^- (meq L^{-1})	0	0	0	0	0	0	0-1
Na^{2+} (meq L^{-1})	1.4945	3.108	13	13	12	16	0-40
Ca^{2+} (meq L^{-1})	0.2106	0.4379	6	6	6	7	0-20
RSC	0	0	0	0	0	0	--
TDS	132.22	274.97	1605	1713	1001	952	--

(54.38%) of farmers whereas, a large number of farmers were found to have good awareness about the health hazards caused by drinking of arsenic contaminated water. The effect of low quality ground water on the crop productivity and reported that wastewater of cities have inhibiting effect on seed setting and yield of the crop [15]. Sairam (2004) reported that the groundwater quality of vineyards around Hyderabad, Andhra Pradesh, India showed soluble salts and chloride contents higher than the permissible limits for agriculture use water in berries orchards [23]. The groundwater cannot be classified a healthy fresh water stream in most of the areas around River Krishni [7]. Such polluted surface water is likely to pollute ground water resources along its path of flow. Efforts have been made in the present investigation to study the interaction of polluted water of River Krishni (India). Reproductive growth of the plants was adversely affected by poor quality groundwater [12].

CONCLUSIONS

- Natural disparity in the determined values for EC, pH, HCO_3^-, CO_3^-, Na^{2+}, Ca^{2+}, $SO4^2$, SAR and TDS in water samples collected from Berani, Usman Shah Huri, Tando Adam and Oderolal area zones, but the analysed levels for these physico-chemical properties for water samples were within the permissible limits of FAO.
- There was an inconsistency in the physico-chemical properties as determined from the first sample study of the soil but the determined values were well below the maximum limits referred by FAO. Hence, it could be considered that the soils of the Berani, Usman Shah Huri, Tando Adam and Oderolal area are normally suitable for crop production.
- In repeated soil analysis (sample-II) zonal disparity and inconsistency in soil properties was observed but mostly were within the permissible limits of FAO with the exception of soil pH in Berani zone, that was higher than the permissible limits of FAO; while in Usman Shah Huri and Tando Adam the soil pH was at par with the FAO limits; while the soils of Oderolal were within the permissible limits for pH value.
- The effect of increased soil EC and pH on the production was obvious and highest banana production was observed in Usman Shah Huri zone and lowest banana production was recorded in Berani zone of the study area
- Higher banana production in Usman Shah Huri zone was mainly associated with lower soil EC and pH value, because recorded pH of Berani region was higher than the FAO permissible limits, and soil EC was also higher than Usman Shah Huri, Tando Adam and Oderolal area.
- The increasing salinity simultaneously increased soil EC and pH values of the soil as well. However, soil contents in regards to HCO_3^-, CO_3^-, Na^{2+}, Ca^{2+}, $SO4^2$, SAR and TDS were normally within the permissible limits for the soil used for agriculture and water for human consumption and irrigation as well.

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