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RESEARCH ARTICLE

ASSESSMENT OF TUBE WELL IRRIGATION WATER QUALITY: A CASE STUDY OF TALUKA THULL DISTT: JACOBABAD, SINDH, PAKISTAN

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ABSTRACT

Irrigation water quality has profound effects on physio-chemical properties of soil, crop productivity, environment and food products. Therefore, an attempt is initiated to evaluate source, availability and quality of tube and canal irrigation of taluka Thull distt: Jacobabad in order to adopt possible best management practices through providing better guidelines to local farmers about quality of tube well and canal irrigation water. The water samples were collected throughout the taluka Thull at distance of 5 square kilometer. Water samples were used to analyze pH, Electrical Conductivity (EC dS m^{-1}), anions such as CO_2^-, HCO_3^-, CL^-, cations such as (Ca^{2+}, Mg^{2+}, Na^+) and Sodium Adsorption Ratio (SAR). Our study revealed that pH was higher than acceptable level in most of the tube well water samples ranged from 7.5 to 9.0. The EC level in tube well water samples were also beyond acceptable level and 75% samples were in hazardous category followed by 25% under marginal category based on the measurement given by WAPDA (1982). Similarly, concentration of anions in tube well water samples were also found under marginal and hazardous categories respectively. Carbonate concentration was observed in tube well water between 1.0 meq/L to 3.2 meq/L. Moreover, Bi-carbonate concentration was recorded between 3.0 meq/L to 8.8 meq/L. Likewise; chloride concentration was recorded between 19.2 meq/L to 60.5 meq/L. In addition, concentration of cations in tube well water samples were also found marginal and hazardous categories respectively. In conclusion, farmers have to take precautionary management practices before using tube well irrigation water.

INTRODUCTION

Agriculture being a major GDP sharing sector in Pakistan occupies central position in economic corridor. It shares more than 24% of Gross Domestic Product (GDP) and accounts 54% of total employment incentives across country. Pakistan has extensive irrigation system in the world. The largest continuous flow of canal system contributes about 82 MAF canal water. More recent, hydrological changes brought about climate change has significantly affected normal precipitation rate across country that has further compelled local farmers to exploit tube well water to meet ever raising demand. Moreover, scare canal irrigation water coupled with increasing demand for cropping intensity and non-agriculture usage of irrigation water over the year has further aggravated the situation.

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Water used for irrigation purpose can vary in quality based upon type and quantity of salts dissolved in water. Salts may be present in irrigation water in relatively small or may be so high. These salts are originated from dissolution of weathering of the rocks and soil, including dissolution of lime, gypsum and other dissolved soil minerals. The suitability of irrigation water is determined not only by the total amount of dissolved salts available in water but also by the kind of dissolved salts. Currently, supplies of irrigation water is facing multiple challenges due to lack of water resource management, booming industries, raising water pollution, climate change and lack of water development projects. Looking at situation, it is reality that in near future supply of good irrigation water may become dream. Irrigation water quality has profound effects over soil physio-chemical and biological properties there by affecting crop productivity. The knowledge of irrigation water quality is very essential for proper soil and crop management. Hence, the study of source, availability and quality of irrigation is gaining popularity across globe. Looking at importance of good quality of irrigation water, a detail study on the irrigation water supply is essentially important for better soil health and optimum crop production. Similarly, in proposed study area, detailed information about subject is lacking. Therefore, there was dire need to conduct a deep and extensive research study in the area, in order to conserve soil resources, maximize crop production, save environment, minimize food insecurity and maximizing farm output on sustainable basis.

METHODS AND MATERIALS

Water samples were taken for determination of irrigation water quality of both tube well and canal water of the taluka Thull. Irrigation water samples were taken randomly from entire taluka Thull at 5 square kilometer approximately. Irrigation water samples were then brought to Soil Science laboratory at Sindh Agriculture University Tandojam for further analysis. The water samples were used to analyze pH, EC (dSm^{-1}) anions (CO^{2-}, HCO_3^-, Cl^-), cations (Ca^{2+}, Mg^{2+}, Na^+), Sodium Absorption Ratio (SAR) and Residual Sodium Carbonate (RSC). Furthermore, results were interpreted while using methods described by the FAO (1985) and WAPDA (1982). Sodium Absorption Ratio (SAR) and Residual Sodium Carbonate (RSC) were determined using following calculation procedures.

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

Electrical Conductivity (EC dS m^{-1}): EC in irrigation water samples determined by using Digital EC meter following method of USSL (1954)

pH: pH of irrigation water samples determined by using Digital pH meter following method of USSL (1954).

Soluble Carbonate: Soluble carbonate in water samples evaluated by using titration with standard H_2SO_4 method described by USSL (1954). Method No. 7, p-94

Soluble Bi-Carbonate: Soluble bi-carbonate is water samples analyzed by using titration with standard H_2SO_4 method described by USSL (1954). Method No. 12, p-98

Soluble Magnesium: Soluble Magnesium was titrated with standard versinate solution. Diagnosis and improvement of saline and alkaline soils. USSL Hand Book No. 60, (1957). Method No.7, p-94.

Soluble Sodium : Soluble sodium was determined by flame photometer. Diagnosis and improvement of saline and alkaline soils. USSL Hand Book No. 60, (1954). Method No.10 and 11a, p-96-97.

Soluble chloride: Soluble chloride was titrated with $AgNO_3$. Diagnosis and improvement of saline and alkaline soils. USSL Hand Book No. 60, (1954). Method No.13, p-98.

RESULTS AND DISCUSSION

EC (dS m^{-1}): The electrical conductivity (EC) of irrigation water indicates amount of soluble salts present in water. The higher electrical conductivity means more salts and ions are dissolved in water. The average value of EC (dS m^{-1}) in all water samples range between 2.2 to 4.5 (dS m^{-1}) as described in Table 2. The minimum electrical conductivity was found in Joungal followed by highest in Karimbux union councils respectively. According to classification of (WAPDA 1982) as described in Table: that 25% tube well water samples were marginal quality, followed by 75% water samples were of hazardous quality respectively.

pH: pH is unit to describe acidity and alkalinity. The value below 7 shows acidity, above than 7 shows alkalinity and value at 7 shows neutral. The water under natural state is neutral. As impurities are added to water its pH value gets changes. The minimum pH of tube well irrigation water was observed in Joungal and highest ph value was observed in Karimbux union councils respectively Table: 2. Moreover, according to guidelines of WAPDA (1982) as given in Table: 2 states that 81% tube well water samples were under desirable category and remaining 19% tube well water samples were of permissible limit.

Soluble carbonate meq L^{-1}: The data relating to soluble carbonate meq L^{-1} of tube well water revealed that maximum 3.2 meq L^{-1} soluble carbonate in tube well water was found in Bachro union council, followed by minimum1.0 meq L^{-1} soluble carbonate in Balochabad union council as described in Table 5. Furthermore, according to classification of soluble carbonate given by FAO (1985) that 56.25% tube well water samples came under above safe limits, followed by 43.75% of useable category.

Soluble bi-carbonate meq L^{-1}

The maximum level of soluble bi-carbonate was observed in Bachro union council that roughly accounts 16.8 meq L^{-1}, followed by minimum 3 meq L^{-1} in Joungal union respectively, Table 2. Moreover, based on guidelines of FAO Table 3 that 31% tube well irrigation water samples were of useable category and remaining 69% water samples were of above safe limits Table 5.

Soluble chloride meq L^{-1}

The soluble chloride remained under range of 19.2 to 60.5 meq L^{-1} Table 2. The highest level of soluble chloride was detected in samples taken from Sherwah union council that accounts 60.5 meq L^{-1}. Similarly, under classification guidelines set out by FAO (1985) that only 6.5% tube well irrigation water samples came under useable category followed by 93.5% of above same limit respectively Table 5.

Soluble calcium meq L^{-1}

The maximum level of soluble calcium was observed in Mubarakpur union council that is roughly estimated at 12.2 meq L^{-1}. Similarly, minimum soluble calcium in tube well irrigation water was detected in water samples taken from Toj union council that accounts 3.4 meq L^{-1}. Table 2. Besides, according to guidelines of FAO (1985) Table 3 that 100% of tube well irrigation water samples came under useable category and none samples were of above safe limits Table 5.

Table 1. Sampling source, Depth, Size of suction pipe of tube well and date of sampling

UCs	Source	Depth-ft	Suction pump size-inch	Date of Sampling
Joungal	Tube Well	80	5 by 4	21-9-2015
Toj	Tube Well	80	6 by 5	21-9-2015
Mirpur	Tube Well	90	5 by 4	22-9-2015
Dinpur	Tube Well	85	6 by 5	22-9-2015
Garhi Hassan	Tube Well	95	7 by 6	24-9-2015
Mubarakpur	Tube Well	80	5 by 4	24-9-2015
Tajo khoso	Tube Well	85	5 by 4	26-9-2015
KotJangu	Tube Well	90	5 by 4	26-9-2015
Rajanpur	Tube Well	80	6 by 5	28-9-2015
Balochabad	Tube Well	80	5 by 4	28-9-2015
Logi	Tube Well	85	6 by 5	29-9-2015
Bachro	Tube Well	85	8 by 7	29-9-2015
KarimBux	Tube Well	95	7 by 6	31-9-2015
Saidokot	Tube Well	90	7 by 5	31-9-2015
Misripur	Tube Well	85	6 by 5	1-10-2015
Sherwah	Tube Well	85	5 by 4	1-10-2015

Table 2. Chemical analysis of tube well irrigation water of Thull town

					(meq L^{-1})				
Union councils	**EC (dS m^{-1})**	**pH**	**(CO_3^-**	**HCO_3^-**	**CL^-**	**Ca^{++}**	**Mg^{++}**	**Na^+)**	**SAR**
Joungal	2.2	7.5	----	3.0	21.8	3.5	1.2	14.4	9.6
Toj	2.5	7.5	----	3.2	19.2	3.4	3.2	15.1	8.3
Saidokot	3.4	8.0	2.1	12.2	58.3	8.5	4.3	30.7	12.2
Sherwah	3.5	8.1	2.2	13.3	60.5	9.3	2.9	42.5	17.3
Mirpur	2.8	7.9	----	5.3	23.0	6.8	2.6	23.7	11.0
Dinpur	3.1	7.9	1.9	6.8	24.0	6.8	2.6	26.5	12.3
Misripur	3.3	8.2	1.0	14.0	27.5	10.5	5.5	28.9	10.2
Logi	3.0	8.3	1.4	14.1	28.9	6.6	2.5	28.1	13.2
Rajhanpur	3.2	8.3	1.6	13.8	23.2	6.0	2.7	29.5	14.2
Tajo Khoso	2.9	8.2	----	14.2	25.4	7.0	3.0	21.2	9.5
KotJangu	4.2	8.5	2.8	15.6	21.8	10.6	5.4	47.3	16.8
KarimBux	4.5	8.7	3.1	16.0	25.5	12.1	6.7	49.1	16.0
G. Hassan	2.9	8.0	----	7.3	42.3	4.6	1.7	22.1	12.5
Bachro	4.3	9.0	3.2	16.8	50.1	10.8	5.8	47.2	16.3
Mubarakpur	4.5	8.7	3.1	16.1	32.0	12.2	6.7	50.4	16.4
Balochabad	3.4	8.1	1.0	13.4	27.2	6.8	2.9	31.1	14.1

---- (not detected)

Table 3. Guideline values given by FAO (1985) and WAPDA 1982

			Guideline values (meq L^{-1})	
Parameters	**Range**	**Mean**	**FAO (1985)**	**WAPDA (1982)**
EC (dSm^{-1})	2.2-4.5	3.1	N/A	(useable<1.5, marginal 1.5-3.0, Hazardous>3.0)
pH	7.5-9.0	8.2	N/A	(Desirable 7.5, Permissible > 7.5-8.0)
CO_3^-	1.0-3.2	1.5	(useable 0-10, above safe limit >10)	N/A
$HCO3^{--}$	3.0-16.8	11.6	(useable 0-10, above safe limit>10)	N/A
Cl^-	19.2-60.5	32.0	(useable 0-20, above safe limit>20)	N/A
Ca^{++}	3.4-12.2	7.8	(useable 0-20, hazardous>20)	N/A
Mg^{++}	1.2-6.7	3.7	(useable 0-05, hazardous>05)	N/A
Na^+	14.4-50.4	15.5	(useable 0-40, above safe limit>40)	N/A
SAR	8.3-17.3	13.1	N/A	(useable<10, marginal 10-18, hazardous >18)

N/A, (not available)

Table 4. Categorization of tube well irrigation water on the basis of guideline values of WAPDA (1982)

Union councils	EC (dS m^{-1})	pH
Joungal	Marginal	Desirable
Toj	Marginal	Desirable
Saidokot	Hazardous	Permissible
Sherwah	Hazardous	Permissible
Mirpur	Marginal	Permissible
Dinpur	Hazardous	Permissible
Misripur	Hazardous	Permissible
Logi	Marginal	Permissible
Rajhanpur	Hazardous	Permissible
Tajo Khoso	Marginal	Permissible
KotJangu	Hazardous	Permissible
KarimBux	Hazardous	Permissible
G. Hassan	Marginal	Permissible
Bachro	Hazardous	Permissible
Mubarakpur	Hazardous	Permissible
Balochabad	Hazardous	Permissible

Table 5. Categorization of tube well irrigation water on the basis of guideline values of FAO (1985)

Union councils	CO_3^-	HCO_3^{--}	CL^-	Ca^+	Mg^{++}	Na^+
Joungal	Useable	Useable	Above safe limit	Useable	Useable	Useable
Toj	Useable	Useable	Useable	Useable	Useable	Useable
Saidokot	Useable	Above safe limit	Above safe limit	Useable	Useable	Useable
Sherwah	Useable	Above safe limit	Above safe limit	Useable	Useable	Hazardous
Mirpur	Useable	Useable	Above safe limit	Useable	Useable	Useable
Dinpur	Useable	Useable	Above safe limit	Useable	Useable	Useable
Misripur	Useable	Above safe limit	Above safe limit	Useable	Hazardous	Useable
Logi	Useable	Above safe limit	Above safe limit	Useable	Useable	Useable
Rajhanpur	Useable	Above safe limit	Above safe limit	Useable	Useable	Useable
Tajo Khoso	Useable	Above safe limit	Above safe limit	Useable	Useable	Useable
KotJangu	Useable	Above safe limit	Above safe limit	Useable	Hazardous	Hazardous
Karimbux	Useable	Above safe limit	Above safe limit	Useable	Hazardous	Hazardous
G. Hassan	Useable	Useable	Above safe limit	Useable	Useable	Useable
Bachro	Useable	Above safe limit	Above safe limit	Useable	Hazardous	Hazardous
Mubarakpur	Useable	Above safe limit	Above safe limit	Useable	Hazardous	Hazardous
Balochabad	Useable	Above safe limit	Above safe limit	Useable	Useable	Useable

Table 6. Categorization of tube well irrigation water on the basis of guideline values of WAPDA 1982

Union councils	SAR
Joungal	Useable
Toj	Useable
Saidokot	Marginal
Sherwah	Marginal
Mirpur	Marginal
Dinpur	Marginal
Misripur	Marginal
Logi	Marginal
Rajhanpur	Marginal
Tajo Khoso	Marginal
KotJangu	Marginal
Karimbux	Marginal
G. Hassan	Marginal
Bachro	Marginal
Mubarakpur	Marginal
Balochabad	Marginal

Soluble magnesium meq L^{-1}: The average concentration of soluble magnesium detected at 3.7 meq L^{-1} in all tube well water samples Table 3. The highest amount of soluble magnesium was observed in Karimbux and Mubarakpur union councils that account 6.7 meq L^{-1} individually Table 2. Similarly, according to guidelines of FAO (1985) that 69% tube well water samples were of useable category followed by 31% of hazardous category respectively Table 5.

Soluble sodium meq L^{-1}: The highest level of soluble sodium was observed in tube well waters samples of Mubarakpur union council that estimated at 50.4 meq L^{-1}, followed by minimum 14.4 meq L^{-1} in Joungal union council respectively Table 2. Moreover, according to guidelines set by FAO (1985) Table 3 that 31% tube well water samples were of hazardous category and remaining 69% samples found under useable category Table 5.

Sodium Adsorption Ratio: The maximum level of sodium adsorption ratio (SAR) was detected in water samples of Sherwah union council that accounted 17.3, while minimum (SAR) was observed in Toj union council that roughly stand at 8.3 respectively Table:5. According to guidelines of WAPDA (1982) that water samples of Joungal and Toj union councils came under useable category followed by other all samples of marginal category respectively Table: 6.

Conclusion

The irrigation water quality has significant impacts on soil and its related environment particularly physical and chemical properties of soil. Irrigation water quality is serious issue in areas where there is unavailability of canal system coupled with poor or brackish underground water. Therefore, it is imperative to assess its quality before exploiting it for irrigation. In conclusion of this research study, it is suggested that most of the tube well irrigation water quality samples of are marginal category. Therefore, local farmers are suggested to evaluate their tube well water before using for irrigation purpose. Amendments are necessary to be taken to mitigate the negative impacts of poor irrigation water on soil and crop production.

Recommendations

1. Before supplying tube well water for irrigation purpose, there should be performed analysis of the quality of irrigation water.
2. Farmers must use gypsum in soil either directly or mixing with water if irrigation water quality is poor.
3. Further extensive research should be carried for assessing irrigation water quality in the area.
4. Farmers may avoid using poor tube well water for irrigation purpose rather exploits canal water.

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