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Assessment of Jhelum Water for Irrigation Purposes: A Plan for a Quality Profile

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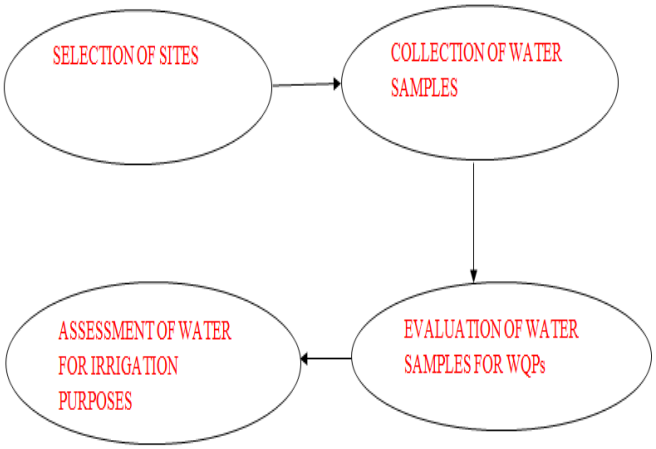
ABSTRACT

Water quality monitoring has been high priority to determine the current conditions of the water system. Water quality indices provide the first hand assessment in a simplified manner on the quality and possible uses for irrigation. Many indices are required for specifying the quality of water for irrigation purposes as a single parameter can be restrictive at times. The intent of this paper was to put forth a quality profile of irrigation water. As a case studied, the water of Jhelum was studied. Samples were collected during the period from October 2016 to April 2017. pH, conductivity, total hardness, nitrite, alkalinity, sodium, magnesium, DO, TDS etc were analyzed. Permeability Index (PI), Kelly's ratio, Sodium Adsorption Ratio (SAR), Magnesium Hazard (MH) was calculated based on the analytical results. It was observed that water quality profile was good and normal for irrigation purposes.

Introduction



Water is an essential component for the survival of life on earth, which contains minerals, important for humans as well as for earth and aquatic life [1]. Water, a prime natural resource and precious national asset, forms the chief constituent of the ecosystem [2]. In agricultural practices, water is an important input for the growth of plants. This input is the basis of planning an intensive system of agricultural exploitation with sustainable characteristics [3]. The kind of water for irrigation has effects on the quality, production and the type of soil. Moreover, irrespective of its source water contains soluble salts and impurities which might render it ideal for domestic purposes but not for agricultural practices, therefore water quality should be verified before putting it to use for agricultural purposes [4]. As a matter of fact, it is worthwhile to mention that water quality is an important criterion as water used in irrigation influences the nature and permeability of soil besides the fertility. In fact, the suitability of water for irrigation depends on the water quality characteristics that ensure maximum yield under good soil and water management practices.

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But the quality characteristics of irrigation water depends upon thewater soluble constituents like calcium, apart from the catchment water balance, soil types, climate, crop tolerance and drainage characteristics [5, 6]. Thus irrigation water influences the crop yield by affecting the soil characteristics like soil permeability, toxicity, texture etc. So quality of irrigation water needs to be evaluated for its suitability in agriculture. The use of the indices is very important to evaluate the quality water, because they relate at least two variables and give a more extended and wide point of view. The indices which relate the salinity risks and hazards were proposed to assess irrigation water quality [7, 8]. These utilize the water quality data and help in the modification of policies, which are formulated by various environmental monitoring agencies. It has been realized that the use of individual water quality variable in order to describe the water quality for common public is not easily understandable [9]. That is why; these techniques have the capability to reduce the bulk of the information into a single value to express the data in a simplified and logical form [10]. Jhelum, which is known as elixir of Kashmir was studied and its water checked for the suitability of irrigation purposes.

Experimental

Sample collection and pre-treatment

The sampling network was designed to cover a wide range of determinates of key sites, which reasonably represent the water quality of the river system. The samples were collected from 8:00 A.M to 10:30 A.M during the period from October 2016 to April 2017. Water samples were collected using open water grab sampler (1.5 L capacity) equipped with a simple pull-ring that allowed for sampling at various depths. In order to determine the water quality, water samples were kept in 5 L polythene cans wrapped with carbon. All water samples were stored in insulated cooler containing ice and delivered

on the same day to laboratory and all the samples were kept at 4^0C until processing and analysis [11].

Chemicals and reagents

Triple distilled water was used throughout the work. All chemicals and reagents were analytical grade, Merck (Darmstadt, Germany). Standard solutions of three elements (i.e. Ca, Mg and Na) were prepared by dilution of 1000 ppm certified standard solutions.

Analytical procedure

Physico-chemical parameters of water, their units and method of analysis are summarized in Table 1. The air temperature, water temperature, pH, EC, salinity, DO, turbidity of each sample were measured at the sampling points following the standard procedures of [12], by using mercury thermometer, digital pH, EC, DO, turbidity meter respectively. In laboratory the water samples were analyzed for other physico-chemical parameters and detection of metal ions (i.e. Ca and Mg). These parameters were analyzed within 48 h, COD determined on the same day of the sampling by utilizing spectroquant TR-320 of Merck at 148 ^{0}C for two hours for heating the COD voils containing mercury(II) sulphte, sulphuric acid and the water samples to be tested. Then the COD measurement was carried out by using Spectroquant NOVA-60 of Merck. While as for evaluating BOD, five day incubation time at 20^0C is a must and is measured by subtracting DO on fifth day from DO on first day multiplied by appropriate dilution factor. Colour was analyzed visually by comparing the water samples with colour standards made of potassiumchloroplatinate (K_2PtCl_6) and cobaltous chloride ($CoCl_2 .6H_2O$) in triple distilled water. TDS and sulphate (SO_4^{2-}) were determined gravimetrically. Total hardness was measured by EDTA complexometry titration and the indicator was Erichrome Black T (EBT) at pH 10 [10]. Total alkalinity determined by acid titration using methyl-orange as end point indicator and chloride content was estimated by silver nitrate ($AgNO_3$) titration using Potasssium Chromate

(K_2CrO_4) solution as an indicator. Free carbon dioxide and total acidity were measured volumetrically by making use of N/44 sodium hydroxide and N/50 sodium hydroxide as standard titrant respectively and phenolphthalein as an indicator in both the cases. Nitritre (NO_2^-) was measured by making use of Spectroquant NOVA-60 of Merck.

Phosphate (PO_4^{3-}) was measured photometrically by making use of Paqualab photometer of ELE International and Palintest tablets of phosphate, HR 114. Calcium and magnesium were determined by Atomic Absorption Spectrometer (AAS) of Perkin Elmer Precisely, AAnalyst 800.

Results and Discussion

Table 2.Values of water quality parameters of Jhelum from October 2016 to December 2016.

Parameters	October 2016	November 2016	December 2016
pH	8.03	7.80	7.79
Colour (hazen)	30	35	20
Electrical conductivity (µS cm^{-1})	336	450	307
Salinity (ppm)	215	288	197
Total Dissolved Solids (ppm)	235	315	215
Total Hardness (ppm)	160	180	132
Turbidity (NTU)	2.20	5.72	0.25
Dissolved Oxygen (ppm)	2.92	3.39	3.25
Chemical Oxygen Demand (ppm)	33.1	52.6	33
Biochemical Oxygen Demand (ppm)	2.2	3.20	0.97
Total Alkalinity (ppm)	124	136	104
Phosphate (ppm)	0	7.5	0
Sulphate (ppm)	19	32	9
Nitrite (ppm)	0.02	0.057	0.05
Free carbon dioxide (ppm)	5	5	3
Acidity (ppm)	10	12	6
Total Chloride (ppm)	13	23	12
Calcium (ppm)	45	40	20
Magnesium (ppm)	12	19	20
Sodium (ppm)	3.11	3.09	1.59

I) The Permeability Index (PI)

The PI is also a useful tool which indicates whether water samples are suitable for irrigation. The classification of water is done as Class I (>75%), Class II (25-75%) and Class III (<25%) to find out suitability of water for irrigation purpose. Irrigated water influenced by Na, Ca, Mg and HCO_3 ion contents affects the permeability of the soil after a long term use. Class I and II are categorized as good water quality for irrigation and Class III as unsuitable for irrigation having a maximum permeability of 25%. The PI was calculated employing the following equation, where all the ions are expressed in meq/L.

Table 1. Water quality parameters associated with their abbreviations, units and analytical methods used.

Parameters	Abbreviations	Units	Analytical methods
pH	pH	pH unit	pH meter
Air temperature	A –Temp	^{0}C	Thermometric
Water temperature	W –Temp	^{0}C	Thermometric
Colour	Colour	Hazen units	Visually
Electrical conductivity	EC	µScm^{-1}	Electrometric
Salinity	Salinity	ppm	Electrometric
Total Dissolved Solids	TDS	ppm	Evap. Method
Total Hardness	T-Hard	ppm	Titrimetric
Turbidity	Turbidity	NTU	Turb metric
Dissolved Oxygen	DO	ppm	Prob. Method
Chemical Oxygen Demand	COD	ppm	Spectroquant photometric
Biochemical Oxygen Demand	BOD	ppm	Prob. method (5 days later)
Total Alkalinity	T-Alk	ppm	Titrimetric
Phosphate	PO_4	ppm	Photometric
Sulphate	SO_4	ppm	Gravimetric
Nitrite	NO_2	ppm	Spectroquant NOVA 60
Free carbon dioxide	Free CO_2	ppm	Titrimetric
Acidity	Acidity	ppm	Titrimetric
Total Chloride	T-Cl	ppm	Titrimetric
Calcium	Ca	ppm	AAS
Magnesium	Mg	ppm	AAS
Sodium	Na	ppm	AAS

Table 3.Values of water quality parameters of Jhelum from January 2017 to April 2017.

Parameters	January 2017	February 2017	March2017	April 2017
pH	7.88	7.97	7.94	7.69
Colour (hazen)	10	21.67	21.67	18.33
Electrical conductivity (µS cm^{-1})	214	285	424.33	300.50
Salinity (ppm)	137	182.50	272	192.67
Total Dissolved Solids (ppm)	150	199.50	297.17	210.33
Total Hardness (ppm)	116	121.33	161.67	121
Turbidity (NTU)	2.55	1.97	2.38	1.43
Dissolved Oxygen (ppm)	4.27	3.83	4	3.17
Chemical Oxygen Demand (ppm)	7.2	18.18	23.28	17.08
Biochemical Oxygen Demand (ppm)	3.09	2.03	2.33	1.59
Total Alkalinity (ppm)	94	96	122.67	101.67
Phosphate (ppm)	8.7	1.37	3.42	1.97
Sulphate (ppm)	23.04	21.77	36.22	15.24
Nitrite (ppm)	0.034	0.02	0.03	0.14
Free carbon dioxide (ppm)	1	2.83	3.50	4.83
Acidity (ppm)	4	6	8	7.83
Total Chloride (ppm)	9	14.33	25	14.67
Calcium (ppm)	32	31.17	34.67	28.83
Magnesium (ppm)	9	10.67	18.83	11.50
Sodium (ppm)	3.11	3.41	3.07	1.63

$$\frac{PI = Na^{+} + \sqrt{HCO_3} \times 100}{Ca^{2+} + Mg^{2+} + Na^{+}}$$

The PI value came out to be 26.24. The water quality falls under Class II, and hence regarded as good for irrigation purposes.

II) Kelly's Ratio (KR)

KR was calculated employing the following equation:

$$KR = \frac{Na^{+}}{Ca^{2+} + Mg^{2+}}$$

Kelly's ratio less than one is generally considered suitable for irrigation. The value was 0.074 and hence fit for irrigation purposes.

III) Sodium Adsorption Ratio (SAR)

The SAR parameter evaluates the sodium hazard in relation to calcium and magnesium concentrations. This parameter is commonly used as an index to evaluate water suitability for irrigation purposes. The SAR was calculated by the following equation:

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

If SAR value is < 10, the water is safe for irrigation with no structural deterioration. On the other hand, the SAR value is > 6-9, the irrigation water will cause permeability problems on shrinking and swelling types of clayey soils. Continued use of water having high SAR leads to breakdown in the physical structure of the soil particles. 0.786 was SAR value and hence fit for irrigation.

IV) Magnesium Hazard (MH)

Magnesium concentration of water plays an important role in determining the quality of water for irrigation purposes and hence, agricultural use. Magnesium hazard was determined by employing the following equation:

$$MH = \frac{Mg^{2+}}{Ca^{2+} + Mg^{2+}}$$

Generally, magnesium hazard more than 50 is considered harmful and unsuitable for irrigation use. The value comes out to be 23.20.

Conclusion

From the above results it is clear that the water of river Jhelum is ideal for irrigation purposes yet the same needs to be checked. An irrigation water quality factor alone is not enough to evaluate potential salinity and hazards which may be confronted under irrigated agriculture. The concept of quality is multiplicative in nature. They can be so different that at times they can be incompatible among themselves. It would be more relevant to discuss the quality profile. This means that instead of a unique value, we can bring many values to reach a better understanding about the kind of water. From the analysis of the different parameters measured and the application of indices and quality norms, we can conclude that the quality profile for water from the river Jhelum is good and fulfills all the requirements for the intended use.

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