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Assessment of irrigation water quality of agriculture technical school, Manjri farm, Pune

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ABSTRACT

A survey was undertaken during the year 2018. Total 72 water sample were collected in three seasons, pre−monsoon (April−2018), monsoon (August−2018) and post−monsoon (October−2018) season and analyzed for pH, electrical conductivity (EC), cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}), anions (CO_3^{2-}, HCO_3^{-}, Cl^{-} and SO_4^{2-}), heavy metals (Ni, Cd and Cr) and water quality indices like sodium adsorption ratio (SAR), residual sodium carbonate (RSC) and Kelley's ratio (KR). The pH and EC of irrigation water samples varied from 7.34 to 8.56 (7.93), 0.29 to 0.68 (0.48) dSm^{-1}, 7.19 to 7.51 (7.31), 0.21 to 0.54 (0.36) dSm^{-1} and 7.13 to 7.35 (7.22), 0.18 to 0.51 (0.33) dSm^{-1}, respectively. The relative abundance of major ions for most of the water samples were $Ca^{2+} > Mg^{2+} > Na^{+} > K^{+}$ for cations, $SO_4^{2-} > Cl^{-} > HCO_3^{-} > CO_3^{2-}$ for anions and Cr> Cd > Ni for heavy metals. The SAR and KR of irrigation water samples varied from 0.81 to 1.21 (1.01), 0.26 to 0.32 (0.29), 0.66 to 0.88 (0.79), 0.23 to 0.35 (0.28) and 0.56 to 0.81 (0.70), 0.20 to 0.33 (0.26), respectively. Correlation matrix indicated that pH and EC were highly correlated with Na^{+}, Ca^{2+}, Mg^{2+}, K^{+}, Cl^{-}, HCO_3^{-}, SO_4^{2-}, Cd and SAR. In general, the analysis of various parameters indicated that quality of irrigation water showed good on the basis of salinity hazard, sodium hazard, bicarbonate hazard and KR, but toxic in Cd and Cr content.

1. INTRODUCTION

Water is a vital constituent, but its quality is seriously in degradation for many years under the influence of various factors of pollution, chemical, organic and micro−biological. These factors are chiefly caused by overcrowded population engendering the diversification of human economic activities. Use of pitiable quality groundwater has become predictable for irrigation to pay off hastily increasing water hassle in many arid and semi−arid areas (Selvam, 2014). The suitability of any source of water for irrigation purpose depends on the quality of water, its elemental composition, type of soil, salt tolerance characteristics of the plants, climate and drainage features of the soil. On similar terms, suitability of groundwater for irrigation purposes is characterized based on its quality, varying both spatially as well as temporally (Adhikari *et al.,* 2012).

The regular pH range for irrigation water is from 6.5 to 8.4, outside this interval, it may source a nutritional disproportion or toxicity. The water irrigation with high salt contributes to modify arable land salt balance and accelerates its salinization. The quantity of salt accretion in the soil is associated with the quantity and quality of irrigation and drainage water (Venkatramanan *et al.,* 2016). The total absorption of dissolved salts varies from a little parts per million (ppm) to several thousands. Most irrigation waters fall within the range of 100 to 1500 ppm, with a few as high as 5000 ppm., the elevated concentrations mortal used on the more tolerant crops. Salinity affects the plant during the reduced water availability and increased water stress, which is reflected by the leaf water potential (Katerji *et al.,* 2000). The assimilation of water by plants decreases when the osmotic pressure increases. The osmotic pressure depends to the salt content or salinity hazard (Selvam *et al.,* 2017). The specific effects may be through nutrition and through toxicity (Sonneveld and Voogt, 2009). Nutrient deficiencies can also occur in plants when high concentrations of Na^+ in the soil reduces the amounts of available K^+, Mg^{2+} and Ca^{2+} (Hu and Schmidhalter, 2005). The alkali hazard is associated with water infiltration problem. Similar to low salinity, excessive sodium in irrigation water also promotes soil dispersion, structural breakdown and infiltration problem (Brady and Weil, 2012). It is well predictable that the salinity of an irrigation water and the SAR have an interactive effect on soil physical properties (Donald *et al.,* 2006). Combinations of SAR and EC were used to predict the permeability hazard of irrigation water (CCME, 2008). Poor quality water if used for a long time can make the soil less productive or even barren, depending on the amount and type of constituents present in it and the texture of the soil (Brady and Weil, 2012). Saline soil occurs not only ever since there is less rainfall accessible to leach and transfer the salts but also because of the immense evaporation rates attribute of arid climates, which have a propensity additional to deliberate the salts in soils and in surface waters. In addition to that, the water irrigation amount applied per hectare is too much because of climate change in this region (Chung *et al.,* 2018). The assessment of water quality gains importance in recent times due to contamination of groundwater, urbanization, industrialization and interference of agricultural activities (Ackah *et al.,* 2011). Unfortunately, in Pune district salinity is extensive in irrigated regions especially in Hadapsar region. Hence, in the present study an attempt was made to assess the quality of irrigation water for Agriculture Technical School, Manjri Farm, Pune.

2. MATERIALS AND METHODS

Agriculture Technical School, Manjri Farm, Pune, comes under plain zone of Maharashtra and is located at 18°29' to 18°30'N latitudes and 73°58' to 73°59'E longitudes. The elevation from above mean sea level is 562 m. The climate is usually hot and is classified as semi–arid tropical the annual rainfall 545 mm. The mean maximum temperature ranged between 34°C to 42°C while annual mean minimum temperature varies from 8°C to 20°C. The mean humidity percentage ranged between 78–95%. In Agriculture Technical School, only two sources for irrigation water both are canal system, one is Mula Mutha river and another is Shewalwadi Nala.

Total 72 irrigation water samples from Agriculture Technical School, Manjri Farm, Pune, were collected for three seasons *i.e.* pre–monsoon (April–2018), monsoon (August–2018) and post–monsoon (October–2018). The irrigation water samples were collected from two sources namely Mula Mutha river and Shewalwadi Nala. The samples were taken at one meter water depth in the middle of canal, they were collected in high–density polyethylene bottles of one liter capacity and immediately after collection of water samples toluene was added to avoid micro–biological deterioration, tightly screwed and brought to the laboratory for further analysis. The pH in water samples was determined by using pH meter (Jackson, 1973). EC was determined by using conductivity meter (Willard *et al.,* 1974), Chlorides (Mohr's method), carbonates and bicarbonates (double indicator method), sulphates (turbidity method), calcium and magnesium (versenate method) were determined by adopting the procedures given by Richards (1954). Sodium and potassium in water samples were determined by using flame photometer. The trace elements were analyzed by atomic absorption spectrophotometer (AAS) (Lindsay and Norwell, 1978) and the water quality indices like SAR (Ayers and Westcot, 1976) RSC (Eaton, 1950) and KR (Kelley's *et al.,* 1940) were calculated using following formulas given by Richards (1954).

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

Where, all the cations are expressed in me L^{-1}.

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

Where, all cations and anions are expressed in me L^{-1}.

$$\text{Kelley's ratio (KR)} = Na^+ / Ca^{2+} + Mg^{2+}$$

Where, all the cations are expressed in me L^{-1}.

Data were input by MS Office Excel 2007 and correlation coefficients were calculated to determine the relationship among various parameters using Statistical Package for Social Science (SPSS) software (Levesque, 2007).

3. RESULTS AND DISCUSSION

The concentration and composition of dissolved constituents in water determines its quality for the use of irrigation. The irrigation water samples were analyzed for various chemical parameters *viz.,* pH, EC, cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+), anions (CO_3^{2-}, HCO_3^-, Cl^- and SO_4^{2-}), heavy metals (Ni, Cd and Cr) and water quality indices like SAR, RSC and KR. The analytical data in terms of range and mean of irrigation water samples collected Agriculture Technical School, Manjri Farm, Pune in Maharashtra during 2018.

pH

The pH is the most important crucial parameter for determining the acidity, neutrality and alkalinity of irrigation water. The pH value was ranged from 7.34 to 8.56 with an average value of 7.93 in pre–monsoon, 7.19 to 7.51 with an average value of 7.31 in monsoon and in post–monsoon it was ranged from 7.13 to 7.35 with an average value of 7.22 (Table 1). Overall data indicate that the pH of these water samples was slightly alkaline in all three seasons. Further data revealed that the pH value of water samples in pre–monsoon was higher than monsoon and post–monsoon season. (Pawari and Gawande, 2015; Ghodke *et al.,* 2016). Analysis of most of the water samples were slightly alkaline in nature and this slightly alkaline pH is mainly due to bicarbonate and not due to carbonate alkalinity (Ahmad and Qadir, 2011). Hydroxyl ions released from HCO_3^- ions played an important role in generation of alkalinity (Bhat *et al.,* 2018). The pH was highly correlated with all parameters except Ni and Cr (Table 8).

Electrical Conductivity (EC)

The most important water quality guideline on crop productivity is the water salinity hazards as measured by electrical conductivity. EC ranged from 0.29 to 0.68 dSm^{-1} with an average value of 0.48 dSm^{-1} in pre–monsoon, 0.21 to 0.54 dSm^{-1} with an average value of 0.36 dSm^{-1} in monsoon and in post–monsoon season it was ranged from 0.18 to 0.51 dSm^{-1} with an average value of 0.33 dSm^{-1} (Table 1). It was observed from the data that the EC of water samples was higher in pre–monsoon as compare to monsoon and post–monsoon season (Patil *et al.,* 2014; Pawari and Gawande 2015). The variation in EC may be ascribed to anthropogenic activities and geochemical processes existing in this region (Naidu *et al.,* 2020). It was observed from Table 2, out of 72 samples 21 water samples categorized as excellent quality grouped under C1 class and 51 water samples were having good quality grouped under C2 class. Further data revealed that 29.17% water samples were safe for irrigation and 70.83% water samples safe for irrigation but need moderate leaching. The EC of irrigation was found positively correlated with Ca^{2+}, Mg^{2+}, Na^+, K^+, HCO_3^-, Cl^-, SO_4^{2-}, Cd and SAR (Table 8).

Table: 1
pH and EC (dSm^{-1}) of water samples

	Pre–monsoon		Monsoon		Post–monsoon	
	pH	EC	pH	EC	pH	EC
Minimum	7.34	0.29	7.19	0.21	7.13	0.18
Maximum	8.56	0.68	7.51	0.54	7.45	0.51
Average	7.93	0.48	7.31	0.36	7.22	0.33
SD	0.57	0.19	0.10	0.13	0.07	0.13
SEm±	0.11	0.04	0.02	0.03	0.01	0.03

Cations Concentration

The concentration of Cations Ca^{2+}, Mg^{2+}, Na^+ and K^+ in irrigation water samples were ranged from 2.70 to 5.00 me L^{-1} with mean value 3.69 me L^{-1}, 1.60 to 3.10 me L^{-1} with mean value 3.69 me L^{-1}, 1.20 to 2.28 me L^{-1} with mean value 1.75 me $L^{-1}$and 0.24 to 0.49 me L^{-1} with mean value 0.36 me L^{-1}, respectively in pre–monsoon, 1.60 to 4.30 me $L^{-1}$with mean value 2.93 me L^{-1}, 0.90 to 2.10 me L^{-1} with mean value 1.41 me L^{-1}, 0.81 to 1.52 me L^{-1} with mean value 1.16 me L^{-1} and 0.14 to 0.34 me L^{-1} with mean value 0.22 me L^{-1}, respectively in monsoon and in post–monsoon it was ranged from 1.30 to 4.00 me L^{-1} with mean value 2.67 me L^{-1}, 0.70 to 2.00 me L^{-1} with mean value 1.26 me L^{-1}, 0.75 to 1.49 me L^{-1} with mean value 1.12 me L^{-1} and 0.10 to 0.33 me L^{-1} with mean value 0.20 me L^{-1}, respectively (Table 3). The order of cationic abundance was observed as: Ca^{2+} >Mg^{2+} >Na^+>K^+. In the pre–monsoon season concentrations of cations were higher than monsoon and post monsoon season (Yadav and Khan, 2013; Ramamohan and Sudhakar, 2014; Verma *et al.,* 2017). Jalali (2010) reported that dissolution of anorthite can contribute to the Ca^{2+} ions in groundwater. Magnesium carbonate ($MgCO_3$) is a possible source of Mg in irrigation water through release of carbonate and hydroxyl ion it also enhances the pH. The high concentration of Na may be attributed to a base exchange reaction and

Table: 2
Categorization of irrigation water samples on the basis of salinity class

Parameters	Values	Salinity classes (EC dSm^{-1})				
		Excellent (C1) (<0.25)	Good (C2) (0.25 to 0.75)	Permissible (C3) (0.75 to 2.25)	Doubtful (C4) (2.25 to 3.00)	Unsuitable (C5) (>3.00)
Number of sample (Percent distribution)	72 (100)	21 (29.17)	51 (70.83)	0	0	0
Suitability of irrigation water		Safe for irrigation	Safe for irrigation but need moderate leaching	Cannot be used on soils with restricted drainage	Unsuitable under ordinary condition	Unsuitable for irrigation

Table: 3
Concentration of soluble cations in irrigation water samples

	Pre–monsoon (me L^{-1})				Monsoon (me L^{-1})				Post–monsoon (me L^{-1})			
	Ca^{2+}	Mg^{2+}	Na^+	K^+	Ca^{2+}	Mg^{2+}	Na^+	K^+	Ca^{2+}	Mg^{2+}	Na^+	K^+
Minimum	2.70	1.60	1.20	0.24	1.60	0.90	0.81	0.14	1.30	0.70	0.75	0.10
Maximum	5.00	3.10	2.28	0.49	4.30	2.10	1.52	0.34	4.00	2.00	1.49	0.33
Average	3.69	2.22	1.75	0.36	2.93	1.41	1.16	0.22	2.67	1.26	1.12	0.20
SD	0.94	0.43	0.46	0.11	1.09	0.41	0.28	0.08	1.06	0.42	0.28	0.08
SEm±	0.19	0.08	0.09	0.02	0.22	0.08	0.06	0.01	0.21	0.08	0.06	0.01

leaching of Na^+ salts like halite during the movement of water through the sediments (Etteieb *et al.,* 2017). The low levels of K in groundwater samples may be ascribed to its tendency to be fixed by clay minerals and to participate in the formation of secondary minerals (Jalali, 2005). The cations Ca^{2+}, Mg^{2+}, Na^+ and K^+ were found positively correlated with HCO_3^-, Cl^-, SO_4^{2-}, Cd and SAR (Table 8).

Anions Concentration

The CO_3^{2-} content was absent in all three seasons. The concentration of anions HCO_3^-, Cl^- and SO_4^{2-} in irrigation water samples were ranged from 0.70 to 1.60 me L^{-1} with mean value 1.08 me L^{-1}, 3.40 to 8.00 me L^{-1} with mean value 5.61 me L^{-1}, and 4.43 to 14.31 me L^{-1} with mean value 9.22 me L^{-1}, respectively in pre–monsoon, 0.30 to 1.20 me L^{-1} with mean value 0.81 me L^{-1}, 2.00 to 6.20 me L^{-1} with mean value 3.89 me L^{-1} and 2.40 to 10.60 me L^{-1} with mean value 6.29 me L^{-1}, respectively in monsoon and in post–monsoon it was ranged from 0.20 to 1.10 me L^{-1} with mean value 0.70 me L^{-1}, 1.80 to 6.00 me L^{-1} with mean value 3.64 me $L^{-1}$and 2.00 to 9.90 me $L^{-1}$with mean value 5.88 me L^{-1}, respectively (Table 4). The relative proportion of anions in irrigation water samples were $SO_4^{2-}>Cl^->HCO_3^->CO_3^{2-}$. In the pre–monsoon season concentrations of anions were higher than monsoon and post–monsoon season (Patil *et al.,* 2014; Pawari and Gawande 2015; Verma *et al.,* 2017). The sulphate ion in groundwater samples might be due to the presence of sulphide bearing minerals and gypsum in aquifer materials, application of sulphate rich fertilizers and industrial wastes (Sridharan and Nathan, 2017). Furthermore, the application of soil amendments like gypsum is expected to be responsible for high sulphate content in the groundwater (Pal *et al.,* 2018). The natural processes like weathering, dissolution of salt deposits could be the possible way of enrichment of irrigation water with higher chloride content in surface water. The non–lithological factors in nature (poor sanitary conditions, irrigation and return flows), chemical fertilizers may also contribute Cl^- concentration. The dominant bicarbonate ion indicates mineral dissolution process. The higher the concentration of bicarbonates may be ascribed to reaction of carbonate minerals with carbon dioxide (CO_2) and dissolution of CO_2 from the possible mechanisms (Houatmia *et al.,* 2016). The low content of carbonates in irrigation water could be due to conversion of carbonates in bicarbonate by the reaction with water. The HCO_3^- was found positively correlated with Cl^-, SO_4^{2-}, Ni, Cd and SAR and Cl^-, SO_4^{2-} were positively correlated with Cd and SAR (Table 8).

Heavy Metals

The concentration of Ni, Cd and Cr in irrigation water samples were ranged from 0.02 to 0.30 mg L^{-1} with mean value 0.13 mg L^{-1}, 0.14 to 0.51 mg L^{-1} with mean value 0.34 mg L^{-1}, and 0.46 to 0.85 mg L^{-1} with mean value 0.63 mg L^{-1}, respectively in pre–monsoon, 0 to 0.26 mg L^{-1} with mean value 0.11 mg L^{-1}, 0.10 to 0.46 mg L^{-1} with mean value 0.31 mg L^{-1} and 0.42 to 0.79 mg L^{-1} with mean value 0.59 mg L^{-1}, respectively in monsoon and in post–monsoon it was ranged from 0 to 0.21 mg L^{-1} with mean value 0.10 mg L^{-1}, 0.08 to 0.37 mg L^{-1} with mean value 0.27 mg L^{-1} and 0.37 to 0.74 mg $L^{-1}$with mean value 0.54 mg L^{-1}, respectively (Table 5). The concentration of Cd and Cr was higher than

Table: 4
Concentration of soluble anions in irrigation water samples

	Pre–monsoon (me L^{-1})				Monsoon (me L^{-1})				Post–monsoon (me L^{-1})			
	Co_3^{2-}	HCO_3^-	Cl^-	So_4^{2-}	Co_3^{2-}	HCO_3^-	Cl^-	So_4^{2-}	Co_3^{2-}	HCO_3^-	Cl^-	So_4^{2-}
Minimum	0	0.70	3.40	4.43	0	0.30	2.00	2.40	0	0.20	1.80	2.00
Maximum	0	1.60	8.00	14.31	0	1.20	6.20	10.60	0	1.10	6.00	9.90
Average	0	1.08	5.61	9.22	0	0.81	3.89	6.29	0	0.70	3.64	5.88
SD	0	0.30	1.97	4.64	0	0.28	1.53	3.08	0	0.25	1.50	2.99
SEm±	0	0.06	0.40	0.94	0	0.05	0.31	0.63	0	0.05	0.31	0.61

Table: 5
Concentration of heavy metals in irrigation water samples

	Pre–monsoon (me L^{-1})			Monsoon (me L^{-1})			Post–monsoon (me L^{-1})		
	Ni	Cd	Cr	Ni	Cd	Cr	Ni	Cd	Cr
Minimum	0.02	0.14	0.46	0	0.10	0.42	0	0.08	0.37
Maximum	0.30	0.51	0.85	0.26	0.46	0.79	0.21	0.37	0.74
Average	0.13	0.34	0.63	0.11	0.31	0.59	0.10	0.27	0.54
SD	0.08	0.11	0.08	0.07	0.11	0.08	0.06	0.10	0.08
SEm	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.01
Permissible limit	0.2	0.01	0.1	0.2	0.01	0.1	0.2	0.01	0.1

recommended maximum concentration (FAO, 1985). In the pre–monsoon season concentrations of heavy metals were higher than monsoon and post monsoon season (Bharti *et al.,* 2013 and Madhukar *et al.,* 2013). The experimental area's irrigation water is highly contaminated with Cr and Cd, which are used to add color and pigment to garments, plastics, and agro–chemicals. The area receives waste water from fabric printing, agro–chemical, pharmaceutical, poultry feed, and fish feed factories, which creates high Cd and Cr concentrations. High recommended doses of phosphatic fertilizers also contributes towards development of concentration of heavy metals particularly Cd and Cr. The heavy metals Ni and Cd were found positively correlated with SAR (Table 8).

Water Quality Indices

The most useful parameter for determining the suitability of groundwater for irrigation purpose with regard Na^+ hazard is the SAR. Sodium measured against calcium and magnesium was considered by (Kelley's *et al.,* 1940) to classify waters for irrigation. KR greater than 1 indicates an excess level of Na^+ in water. Therefore, water with the KR less than 1 is suitable for irrigation. The SAR and KR of irrigation water samples ranged from 0.81 to 1.21 with mean value 1.01 and 0.26 to 0.32 with mean value 0.29, respectively in pre–monsoon, 0.66 to 0.88 with mean value 0.79, and 0.23 to 0.35 with mean value 0.28, respectively in monsoon and in post–monsoon it was ranged from 0.56 to 0.81 with mean value 0.70 and 0.2 to 0.33 with mean value 0.26, respectively (Table 6). In the pre–monsoon season SAR and KR were higher than monsoon and post–monsoon season (Deshpande and Aher, 2012; Yadav and Khan, 2013; Verma *et al.,* 2017). According to sodicity classes (SAR) 100% water samples were grouped in S_1 category and safe for irrigation purpose (Table 7). All irrigation water samples suitable for irrigation because KR was found less than one. RSC value of all water samples was lower than 1.25 me L^{-1} which was safe and suitable for irrigation. Similar findings were previously reported by Jafer (2013). The SAR was highly correlated with all parameters except Cr and KR positively correlated with Ca^{2+} and SAR (Table 8).

Table: 6
SAR and KR of water samples

	Pre–monsoon		Monsoon		Post–monsoon	
	SAR	KR	SAR	KR	SAR	KR
Minimum	0.81	0.26	0.66	0.23	0.56	0.20
Maximum	1.21	0.32	0.88	0.35	0.81	0.33
Average	1.01	0.29	0.79	0.28	0.70	0.26
SD	0.16	0.02	0.08	0.04	0.06	0.04
SEm±	0.03	0.004	0.01	0.008	0.01	0.008

Table: 7
Categorization of irrigation water samples based on SAR values

Water quality class	Range of SAR	Suitability for irrigation	Percent of irrigation water samples	No. of irrigation water samples
S_1	<10	Safe	100	72
S_2	10 to 18	Moderately safe	0	0
S_3	18 to26	Moderately unsafe	0	0
S_4	>26	Unsafe	0	0

4. CONCLUSIONS

The investigation indicates that pH of all samples of irrigation waters is slightly alkaline considered permissible for irrigation purposes. However, based on EC values, the irrigation water is classified into different classes between excellent class (C1) and good class (C2) of salinity hazard. The result also revealed that suitability of water quality of Agriculture Technical School, Manjri Farm, Pune, was found good for irrigation purpose on the basis of salinity hazard, sodium hazard, bicarbonate hazard and Kelley's ratio, but toxic in Cd and Cr content. The various parameters of irrigation water *viz;* pH, EC, cations, anions and heavy metals parameters were high in pre–monsoon than monsoon and post–monsoon season because of dilution of irrigation water decrease due to high evaporation rate.

Further, this research appears it will integrate the real mechanism of the physico–chemical parameter's interactions with irrigation water modeling. In future, the continuous environmental monitoring includes determination through recent models such as time series analysis, artificial neural network and fuzzy GIS which are essential for identifying and preventing pollution in this area. The assessment of irrigation water in every nook and corner of the country is a prerequisite for its better utilization.

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Table: 8
Correlation matrix between water quality parameters

	pH	EC	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	So_4^{2-}	Ni	Cd	Cr	SAR
EC	0.808**												
Ca^{2+}	0.708**	0.958**											
Mg^{2+}	0.818**	0.812**	0.812**										
Na^{+}	0.913**	0.923**	0.892**	0.913**									
K^{+}	0.875**	0.887**	0.866**	0.899**	0.944**								
HCO_3^{-}	0.773**	0.859**	0.862**	0.825**	0.849**	0.858**							
Cl^{-}	0.825**	0.963**	0.932**	0.848**	0.927**	0.904**	0.885**						
So_4^{2-}	0.827**	0.981**	0.942**	0.801**	0.920**	0.875**	0.859**	0.956**					
Ni	0.227	0.160	0.118	0.152	0.144	0.183	0.260*	0.213	0.150				
Cd	0.544**	0.709**	0.723**	0.644**	0.690**	0.609**	0.699**	0.720**	0.700**	0.117			
Cr	0.216	0.064	0.053	0.255*	0.158	0.216	0.195	0.089	0.055	0.179	?0.054		
SAR	0.916**	0.778**	0.718**	0.839**	0.923**	0.869**	0.735**	0.803**	0.777**	0.239*	0.610**	0.224	
KR	0.257*	−0.210	0.358**	−0.084	0.020	−0.039	−0.183	−0.183	−0.174	0.125	−0.131	0.153	0.338**

*Significant at 5% level; ** Significant at 1% level

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