ASSESSMENT OF THE PHYSICO-CHEMICAL PARAMETERS OF SURFACE WATER SAMPLES IN BIRJAND FLOOD PLAIN, IRAN

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Abstract

The physico-chemical status of twelve surface water samples from the Birjand flood plain of eastern Iran during the November 2010 were assessed. The sampling points were selected on the basis of their importance. The physico-chemical parameter like, pH, temperature (T), electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), sulphate (SO_4^{2-}), phosphate (PO_4^{3-}), bicarbonate (HCO_3^{-}), carbonate (CO_3^{2-}), nitrite (NO_2^{-}), nitrate (NO_3^{-}), dissolved oxygen (DO), biological oxygen demand (BOD_5), and chemical oxygen demand (COD) of surface water were determined. Results showed that the quality of surface water not suitable for drinking, with references to the concentrations of EC, TDS, TH, Na^{+}, HCO^{3-}, and BOD_5 which are more than the prescribed limits, in most sites. Results also indicated that there were correlations among the measured parameters.

KEYWORDS: Water Quality, Hardness, BOD_5, Birjand Flood Plain

Introduction

Today the competition for scarce water resources is intense both in Iran and in many places all over the world, because water is most essential commodity for human consumption and is one of the most important renewable resources, which must be prevented from deterioration in quality. The East part of Iran has a semi- arid climate with little rainfall (annual average 171 mm), so communities must share freshwater sources from aquifer systems. Water source is one of the most important limiting factors in the arid and semi-arid regions that can exhibit the development of sustainable. Many of people around the world enjoy the benefits of technological and economic developments and high standards of living, however, many scientists are aware that these developments cost a lot. Development of human societies and industry result in bioenvironmental problems specially the source of water pollution.

Sources of drinking water such as streams, rivers, lakes, dams, reservoirs and groundwater may be contaminated either directly or indirectly by human activities. The main sources of water pollution are discharge of domestic sewage and industrial effluents, which contain organic pollutants, chemicals and heavy metals, and run-off from land-based activities (Goldar and Banerjee 2004). Increasing water pollution causes not only the deterioration of water quality but also threatens human health and the balance of aquatic ecosystems, economic development and social prosperity (Milovanovic 2007). Considering the effects of human activities on water quality and monitoring, it is of high necessity to notice the water sources quality (Mansouri et al. 2011). Monitoring can be the first and the most important step toward applying an appropriate quality management plan in order to elimination water pollution (Sanchez et al. 2007). Good quality of water resources depends on a large number of physico-chemical parameters and the magnitude and source of any pollution load and to assess that monitoring of these parameters is essential (Reddi et al. 1993). Assessment of water resource quality of any region is an important aspect of developmental activities of the region, because rivers, lakes and man-made reservoirs are used for water supply to domestic, industrial, and agricultural (Jakher and Rawat 2006). Hence, the objective of this article was to investigate the physico-chemical parameters (pH, T, EC, TDS, TH, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, SO_4^{2-}, PO_4^{3-}, HCO_3^{-}, CO_3^{2-}, NO_2^{-}, NO_3^{-}, DO, BOD_5, and COD) of surface water in Birjand flood plain in the eastern Iran. The analyzed data were compared with standard values recommended by WHO for drinking purposes.

Materials and Methods

The studied site is located in East of Iran, Birjand, and the capital city of Southern Khorasan province. It is situated at latitude of 32˚ 86' N and longitude of 59˚ 21' E and about 1490 m above sea level. The climate of the city is semi- arid with cold winter and approximately 8 months dry season (from middle of April to December). Its average rainfall is 171 mm and unevenly distributed throughout the year. The average annual temperature is 16.5 ºC with the warmest month in July (average 28.5 ºC) and the coldest in January (average 3.5 ºC). The sunlight of the year is 255 days.

Water samples were collected from 12 sites in the Birjand flood plain in the November 2010. Water samples were collected into acid washed 250-ml plastic bottles. The samples were kept in refrigerator maintained at 4 ^{o}C. The water samples were filtered using a 0.45 μm nitrocellulose membrane filter. Prior to any analysis, all equipment and containers were soaked in 10% HNO_3 and rinsed thoroughly with deionized distilled water before use. Water temperature was measured at the time of water sample collection using an ordinary thermometer. The physico-chemical parameters such as pH, EC, TDS, TH, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, SO_4^{2-}, PO_4^{3-}, HCO_3^{-}, CO_3^{2-}, NO_2^{-}, NO_3^{-}, DO, BOD, and COD were determined using standard methods (APHA 1989; WHO 1993 and WHO 2008). The methods used for estimation of various physico-chemical parameters are tabulated in Table 2. Finally, the resulted data was compared with the WHO standards specified for the maximum rate of physicochemical parameters allowed in drinking water. Statistical analyses were carried out using SPSS ver. 16.0. A Pearson correlation (*r*) was used to test correlations. All concentrations are reported in mg/l except pH, EC (in micromhos/ cm), and temperature (in ^{o}C).

Results and Discussion

pH and Water Temperature

Measurement of pH is one of the most important and frequently used tests in water chemistry. pH is an important factor in determining the chemical and biological properties of water. It affects the chemical forms and environmental impact of many chemical substances in water (Weiner 2007). PH of surface water was alkaline and with an average pH of 8.3 (Table 2). They were within the limits (WHO Standard; 7-8.5). The increase in pH can be attributed to organic pollution and the domestic waste discharge draining into the river system as it traverses the habited city.

Temperature is an important factor and all life processes are accelerated or slowed down by temperature changes in the environment. It influences the solubility of gases and salts in water. Most chemical equilibria are temperature dependent. Important environmental examples are the equilibria between ionized and unionized forms of ammonia, hydrogen cyanide, and hydrogen sulfide (Weiner 2007). The water temperature recorded from groundwater Birjand flood plain showed only slight variations. Average water temperature of groundwater varied from 25.4 to 27.8 ºC (Table 2).

TDS

Total dissolved solids (TDS) indicate the general trend of the surface quality or salinity of the surface water bodies. In natural waters, the major contributors to TDS are carbonate, bicarbonate, chloride, sulfate, phosphate, and nitrate salts (Weiner 2007). During the present study, minimum values of TDS were recorded at site 9 (1145 mg/l) and maximum at site 8 (2960 mg/l). This may be due to natural sources and urban runoff from the sampling sites (Rai et al. 2011). Water with a TDS < 1200 mg/L generally has an acceptable taste. Higher TDS can adversely influence the taste of drinking water and may have a laxative effect (Weiner 2007).

Total Hardness, Calcium, and magnesium (Ca^{2+}, Mg^{2+})

Total Hardness ranged from 339-893 $mgCaCo_3$/L, the highest and lowest was recorded at site 8 and site 9, respectively (Table 2). It might be due to the dissolution of land derived carbonates and bicarbonate in the water. Hard water is water that contains high levels of dissolved calcium, magnesium and other mineral salt such as iron. The concentration of Ca^{2+} and Mg^{2+} observed from the studied area is varied from 30 to 200 $mgCaCo_3$/L and 42 to 148 $mgCaCo_3$/L, which is below the standard limit of 200 and 150 $mgCaCo_3$/L in the surface water samples, respectively (WHO 2008). The Ca^{2+} is an important element to develop proper bone growth. Although, Mg^{2+} is an essential ion for functioning of cells in enzyme activation, but at higher concentration, it is considered as laxative agent (Subba Rao et al. 2011).

Sodium (Na^+)

The sodium varied from 91 to 651 mg/l the amount present do exceed the maximum permissible limit i.e. 200 mg/l for drinking water prescribed by WHO (Table 2). It makes the water unsuitable for drinking, because it causes severe health problems like hypertension (Holden 1970). Surface water in most of the study area comes under the non-safe zone for drinking, with reference to the concentration of Na^+, which is more than 200 mg/L. Therefore, sodium restricted diet is suggested to the patients, who suffer from the heart diseases and also from the kidney problems (Subba Rao et al. 2011).

Potassium (K^+) and Chloride (Cl^-)

Potassium of water samples collected lies in the range from 1.1 to 1.8 mg/L. It maintains fluids in balance stage in the body. High potassium values may cause nerviness and digestive disorder (Tiwari 2001).

The chloride varied from 266 to 923 mg/l the amount present do exceed the maximum permissible limit i.e. 600 mg/l for drinking water prescribed by WHO. In the other hands, the chloride levels in unpolluted waters are often below 10 mg/l (Tebbut 1992), but mean concentrations observed in this study ranged from 266 to 923 mg/l. In high concentrations, chlorides in urban areas are indicators of large amounts of non-point pollution; pesticides, grease and oil, metals and other toxic materials with high levels of chloride.

Bicarbonate (HCO_3^-)

The chemical data show that the concentration of HCO_3^- (336 to 671 mg/L) is 1.12 to 2.23 times higher than that of the desirable limit of 300 mg/l in the surface water samples (Table 2). The HCO_3^- has no known adverse health effects on human health, if it exceeds 300 mg/L in the drinking water, in general. However, it should not exceed 300 mg/L in the potable water, as it may lead to kidney stones in the presence of higher concentration of Ca^{2+}, especially in dry climatic regions (Subba Rao et al. 2011).

Nitrate (NO_3^-) and nitrite (NO_2^-)

Maximum concentration of NO_3^- was observed at station 2 and minimum was at Station 5. Presence of NO_3^- ion could be due to the anthropogenic sources, namely; domestic sewage, agricultural wash off and other waste effluents containing nitrogenous compounds (Prasanna and Ranjan 2010). A high NO_3^- concentration in water not only induces environmental eutrophication under certain conditions, but is also a causative factor in methemoglobinemia and cancers (Babiker et al. 2004; Peng et al. 2011).

Dissolved oxygen (DO)

The value of DO fluctuates from 1.9 mg/l to 15.5 mg/l (Table 2). The maximum values were recorded at site 4 and minimum values were at site 8. The high DO is due to increase in temperature and duration of bright sunlight has influence on the % of soluble gases (O_2 & Co_2) (Manjare et al. 2010). Oxygen is one of the most important in any living ecosystem. The amount of dissolved oxygen in water depends on surface are exposed, temperature etc. Dissolved oxygen is an important factor in assessing water quality. Oxygen becomes dissolved in surface waters by diffusion from the atmosphere and from aquatic-plant photosynthesis. Dissolved oxygen is consumed by the degradation (oxidation) of organic matter in water (Al Sabahi et al. 2010).

Biological oxygen demand (BOD_5) and chemical oxygen demand (COD)

The biochemical oxygen demand was ranged from 7 to 15.6 mg/l and chemical oxygen demand was between 9.9 and 33 mg/l (Table 2). Measurement of BOD has long been the basic means of determining the degree of organic pollution in aquatic systems, and a river is said to be unpolluted if its water has a BOD_5 of 2 mg/l or less (Chigor et al. 2011). BOD is an indicator of the potential for a water body to become depleted in oxygen and possibly become anaerobic because of biodegradation. Water with a high BOD may not support aquatic life, unless there is a means for rapidly replenishing dissolved oxygen (Weiner 2007).

In order to quantitatively analysis and confirm the relationship among physico-chemical parameters of surface water samples, Pearson's correlation analysis was applied to the data (Tables 3). Correlation is the mutual relationship between two variables. Direct correlation exists when increase or decrease in the value of one parameter is associated with a corresponding increase or decrease in the value of other parameter (Karunakaran et al. 2009). A significant positive correlation was found between pH with DO. pH and temperature showed negative correlation with most of the parameters. EC showed highly significant positive correlation with TDS, TH, Ca^{2+}, Na^{+}, and Cl^{-}. This suggests that electrical conductivity depends on dissolved solids which depend on salts compound (Shah et al. 2007) such as NaCl, $CaCl_2$. The strong positive correlation (r=0.89) between electrical conductivity, TDS and chloride reflects the fact that chloride increases the electrical conductivity of water, and thus its corrosivity (WHO 2008). TDS showed significant correlation with TH, Ca^{2+}, Na^{+}, and Cl^{-}. The significant correlation between TDS and chloride reflects the fact that chloride is one of the principal anionic constituents of dissolved solids. Moderately positive correlations were found between hardness and Ca^{2+}, Na^{+}. So it may be suggested that total hardness of the experimental water samples may be due to presence of salts of these ions (Bhoi et al. 2005). There were a moderately positive correlation between Ca^{2+} and Na^{+} and Cl^{-} ($P< 0.05$), and, between Cl^{-} and BOD_5 ($P< 0.05$) also, there was a moderately positive correlation between SO_4^{2-} and DO ($P< 0.05$). Highly positive correlations were found among between Na^{+} and Cl^{-} ($P< 0.01$), and, between HCO_3^{-} and NO_3^{-} ($P< 0.01$).

Conclusion

The concentrations of EC, TDS, TH, Na^{+}, HCO^{3-} , and BOD_5 are above the recommended limits prescribed for drinking water in many sites.

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Table (1): Methods used for estimation of physicochemical parameters

Parameters	Test methods
pH	Multi Parameter Analyzer (Consort, Model: C534T& Istek, Model: pdc815)
EC	Multi Parameter Analyzer (Consort, Model: C534T& Istek, Model: pdc815)
TDS	Multi Parameter Analyzer (Consort, Model: C534T& Istek, Model: pdc815)
TH	Titration method
Ca^{2+}	Titration
Mg^{2+}	Titration
Na^{+}	Flame Photometric method
K^{+}	Flame Photometric method
Cl^{-}	Argentometric titration
SO_4^{2-}	Photometer
PO_4^{3-}	Titration
HCO_3^{-}	Titration
CO_3^{2-}	Titration
NO_2^{-}	Photometer
NO_3^{-}	Photometer
DO	Multi Parameter Analyzer
BOD_5	5 days incubation at 20 °C and titration of initial and final DO
COD	Open reflux method

Table (2): Levels of the physicochemical parameters in surface water samples

Parameter	Station												Overall mean	WHO 2008
	1	2	3	4	5	6	7	8	9	10	11	12		
pH	**8.5**	**8**	**8**	**8.6**	**8.1**	**8.9**	**8.7**	**8.2**	**8.4**	**8.1**	**8.5**	**8.7**	**8.3**	**6.5-9.5**
T	15	17	16	16	15	15	16	15	16	16	15	17	15.7	-
EC	3820	1983	2710	1848	1798	2650	2350	4640	1794	4000	3820	1948	2780	1400
TDS	2440	1267	1731	1180	1150	1690	1500	2960	1145	2552	2440	1383	1786	1000
TH	594	394	542	342	694	346	741	893	339	642	594	370	541	500
Ca^{2+}	110	90	110	50	80	30	30	200	50	120	110	70	86	200
Mg^{2+}	78	42	66	54	120	66	148	72	54	84	78	54	75	150
Na^{+}	602	270	370	262	91	447	194	651	250	620	602	270	385	200
K^{+}	1.3	1.4	1.3	1.2	1.1	1.5	1.7	1.8	1.6	1.1	1.3	1.3	1.3	10
Cl^{-}	834	301	639	266	372	532	408	674	301	923	834	286	530	600
SO_4^{2-}	321	144	124	240	43	168	240	100	117	264	321	230	192	400
HCO_3^{-}	488	671	396	366	337	487	427	427	427	518	488	377	454	300
NO_2^{-}	0.01	0.02	0.02	0.01	0.02	0.08	0.07	0.01	0.06	0.01	0.01	0.01	0.02	<0.1
NO_3^{-}	11.7	19.9	5.1	2.8	2.7	8.2	10.1	11.6	11.7	2.8	11.7	3.8	8.5	45
DO	9.4	3.7	6.9	15.5	2.5	10.3	7.1	1.9	2.4	8.5	9.4	13.5	7.5	-
BOD_5	15	9.5	15.6	7	9	14	14	10	10	11	15	8	11.5	-
COD	9.9	18	16.9	11	15	18	24	15	15	33	9.9	13	16.5	-

(All parameters are in mg/l except pH, T and EC in micromhos / cm, Temperature in ^oC).

Table (3): Pearson's correlation coefficients of parameters surface water in Birjand flood plain

	pH	T	EC	TDS	TH	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	SO_4^{2-}	HCO_3^{-}	NO_2^{-}	NO_3^{-}	DO	BOD_5	COD
pH	**1**																
T	-0.12	1															
EC	-0.15	-0.52	1														
TDS	-0.13	-0.50	0.99**	1													
TH	-0.33	-0.48	0.63*	0.63*	1												
Ca^{2+}	-0.53	-0.29	0.77**	0.77**	0.68*	1											
Mg^{2+}	0.17	-0.31	0.04	0.02	0.63*	-0.15	1										
Na^{+}	-0.03	-0.43	0.94**	0.94**	0.34	0.65*	-0.22	1									
K^{+}	0.24	-0.08	0.15	0.15	0.24	0.18	0.13	0.08	1								
Cl^{-}	-0.18	-0.53	0.89**	0.88**	0.50	0.53	0.10	0.87**	-0.14	1							
SO_4^{2-}	0.45	-0.01	0.35	0.36	-0.07	-0.13	0.04	0.46	-0.22	0.46	1						
HCO_3^{-}	-0.27	0.20	0.19	0.17	-0.11	0.08	-0.25	0.28	0.03	0.21	0.16	1					
NO_2^{-}	0.49	-0.08	-0.34	-0.[illegible]6	-0.21	-0.60*	0.31	-0.32	0.53	[illegible]0.30	-0.21	0.[illegible]1	1				
NO_3^{-}	-0.11	0.07	0.13	0.15	-0.0	0.16	-0.18	0.16	0.54	[illegible]0.01	0.0	0.73**	0.16	1			
DO	0.68*	[illegible].17	-0.09	-0.07	-0.46	-0.39	-0.19	0.08	-0.40	-0.01	0.68*	-0.23	-0.15	-0.45	1		
BOD_5	0.11	-0.44	0.43	0.4	0.4	0.01	0.30	0.42	0.15	0.63*	0.3	0.16	0.27	0.1	-0.02	1	
COD	-0.24	0.23	0.13	0.12	0.24	-0.04	0.35	0.05	-0.0	0.22	-0.3	0.27	0.24	-0.16	-0.17	0.0	1

*Correlation is significant at the 0.05 level

**Correlation is significant at the 0.01 level