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Seasonal Hydrogeochemical Characteristics of Gharana Wetland in Jammu Province, J&K, India

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Abstract In the present study, geochemical characteristics of surface water have been studied considering seasonal variation at Gharana Wetland in Jammu Region. Water samples from 6 different sites of the Gharana wetland were collected and analyzed for bicarbonate, chloride, sulfate, nitrate, fluoride, phosphate, calcium, magnesium, sodium, potassium and total hardness. The analytical precision for the measurements of major ions is better than ± 5%. Anions concentration in winter season varied in the order of SO^-_4 > CI^- >F^- whereas the cations followed the varied as Ca^{2+} > Mg^{2+} >K^+ >Na^+. Similarly, the anions showed a decrease in the order as HCO^-_3 > SO^-_4 > CI^- > PO^-_4 > NO^-_3 during summer and cations decreased as Ca^{2+} > K^+ > Na^+ > Mg^{2+}. During monsoon, the anions followed the trend as HCO^-_3 > SO^-_4 > CI^- >PO^-_4> NO^-_3 HCO^-_3 >SO^-_4 > CI^{--} > PO^-_4 NO^-_3 > F^- and cations as K^+> Ca^{2+} > Mg^{2+} > Na^+. This distinct seasonal fluctuations in the ionic concentrations can be ascribed to the fact that source of dissolved material to the wetland varies during the 3 seasons.

Keywords Hydrogeochemistry, Chromatograph, Hardness, Weathering.

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WWF-India, Western Himalayan Landscape

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Introduction

Wetlands are incredible ecosystems providing many tangible and intangible goods and services to human civilization and welfare (Poff et al. 2002). Their healthy existence is seriously threatened by the increased anthropogenic interferences since. It is estimated that, around 50% of the earth's wetlands may have already disappeared worldwide over the last hundred years under intense anthropogenic pressure (Prabaharan et al. 2013). The Ramsar Convention defined wetlands as areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed 6 metres (Ramsar Convention 2006). Wetlands have vital ecological and functional role in environment. Biogeochemical processes occurring in wetland ecosystems regulates various global biogeochemical cycles, including global warming, carbon sequestration and water quality. Wetlands are highly efficient in filtering out suspended solids in the water owing to characteristically dense plant growth and abundant surface litter (Khadka and Ramanathan 2013). Wetlands connected to the groundwater systems or aquifers are protecting water quality by trapping sediments and retaining excess nutrients. However, the majority of the water bodies in the vicinity of human habitations face the major threats of extinction from immense anthropogenic pressure. The chemical changes in water and sediments seriously affect the fish and other aquatic biota. Due to flooded or reducing conditions, wetlands can also support biogeochemical processes that limit organic matter turnover, thus serving as important global carbon sinks. The current study has been undertaken to investigate the affect of anthropogenic activities on the water quality of Gharana wetland, an important site for migratory birds and located in Jammu region.

Study area

Gharana is a small wetland near the International border with Pakistan in the R.S. Pura sector of Jammu, J and K. The wetland is located in the periphery of Gharana village (32.5411282^{0}N 74.6909402^{0}E) from whose name this wetland drives its name. Wetland is surrounded by agricultural fields in 3 sides and village boundary on 1 side. Being close to the village, the wetland is threatened by large encroachments by the local villagers through the extension of their agricultural field boundaries. Total area of the wetland as per the records is 0.75 Km^2, according to the figures provided by the Department of Wildlife Protection, Govt. of J and K. However, the open water area of the wetland is limited in the middle, surrounded by a large expanse of swamps which towards periphery which further merge with the agricultural fields. Lately, this wetland has become a matter of disagreement between the locals and the Department of Wildlife Protection, Govt. of Jammu and Kashmir over the ownership of the land. Gharana wetland receives water through a kucchhanullah originating from the security ditch, a sort of canal made for security reasons near Indo-Pak international water. It also receives overflow water from the surrounding agricultural fields especially when a rains. Even though small, Gharana wetland is immensely important due to the fact that it hosts a large number of migratory birds many of which are globally threatened and facing extinction. The wetland is visited by a large number of migratory birds in winter. The numbers of birds, at times, have been reported to be even exceeding 20,000 at a single point of time. Owing to the presence of birds and closeness to the international border with Pakistan, this wetland holds enormous potential to be developed as a tourism destination. Apart of being a suitable habitat for numerous species of migratory birds, Gharana is harbors a healthy population of turtles, snakes, amphibians and fish. The surrounding swamps have ample growth of aquatic vegetation which provides nesting and feeding ground to the birds and other animals.

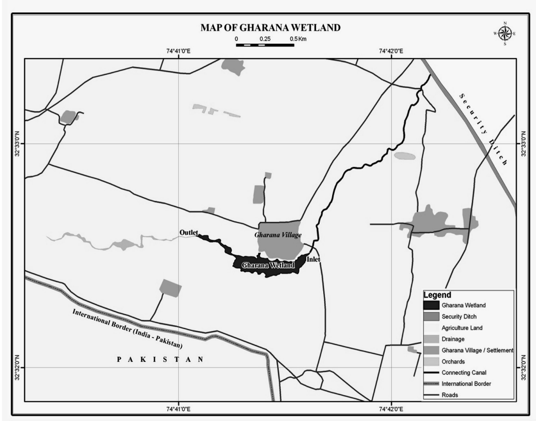


Fig. 1. Location of Gharana Wetland.

Materials and Methods

Experimental details

Water samples were collected in pre-cleaned dry Polyethylene tere phthalate (PET) bottles of 1000 ml capacity from 6 different sites using boat in Gharana wetland. The sampling bottles were carefully filled

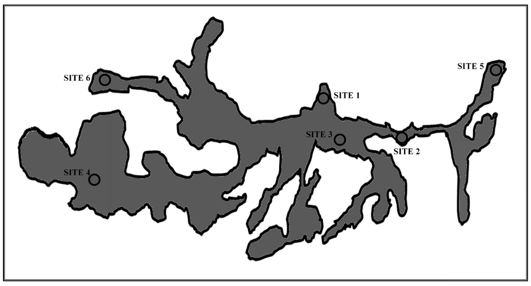


Fig. 2. Showing water sampling sites in the Gharana Wetland.

ensuring no air bubble is trapped inside. Samples were properly labelled and immediately transported to the laboratory. All samples were filtered to separate the suspended sediments. Sampling was repeated for 3 seasons: Winter, summer and monsoon season. Winter sampling was done in the month of late October, 2012, summer sampling in April, 2013 whereas, the monsoon samples were collected during the first dry period after first monsoonal showers in the first week of July. Figs 1 and 2 shows the various sampling locations in the Gharana wetland. Site 5 represents the inflow location of water into the wetland from security ditch, while site 6 represents the near outlet location of water from wetland. Site 1 show the near entry of village drain carrying waste water from the village. The water samples analysis for cation and anion for the winter, summer and monsoon seasons was carried out using (Metrohm 850 Professional IC), Ion Chromatograph at Department of Environmental Sciences, University of Jammu. Before performing the analysis, ion chromatograph was calibrated using anion mixture standard and cation mixture standard. All samples were filtered using filter having pore size equal to 0.2 µm before placing them in the auto-sampler of Ion Chromatograph. Total permanent water hardness was calculated as sum of calcium and magnesium hardness. The detalis of Ion Chromatograph parameters are provided in the Tables 1 and 2. After calculating the hardness, the hardness has been classified as per Table 1. pH were measured by using WTW Multi 340i, SET water analysis kit. Major cations including Na^+, Ca^{2+}, K^+, Mg^{2+} and major anions including HCO_3^- F^-, Cl^-, NO_3^-, SO_4^{2-}, PO_4^{2-} and Br^- were analyzed using Ion Chromatograph whereas HCO_3^- concentrations were determined titrimetrically.

Results and Discussion

Seasonal concentrations of major ions in the Gharana wetland are provided in the Table 2 and also illustrated in Figs. 3.1-3.6. The analytical precision for the measurement of major ions is better than ±5%. Anion concentration in winter varied in the order SO_4 > Cl > F^-, whereas, the cations followed the varied as Ca^2 > Mg > K > Na. Likewise, the anions showed a decrease in the ordered as HCO^3 $>SO^4>Cl>PO^4>NO^3>F$ during summer and cations decreased as Ca>K>Na>Mg. During monsoon, the anions followed the trend as $HCO^3 > SO^4 > Cl > PO^4$ $>NO^3>F$ and cations as K>Ca>Mg>Na. The distinct seasonal fluctuations in the ionic concentrations can be ascribed to the fact that the source of dissolved material to the wetland varied during the 3 seasons. Atmospheric precipitation is an important source of dissolved substances especially during the monsoon season. Urban and agricultural runoff facilitated by precipitation also add large amount of dissolved load

Table 1. Chromatograph parameters during analysis.

Parameters		Cations	Anions
Data source		Conductivity detector l (850 Professional IC l)	Conductivity detector 1 (850 Professional IC l)
Recording time		21.0 mins.	28 mins.
Column type		Metrosep C 4 - 150/4.0	Metrosep A Supp 5 - 250/4.0
	Eluent A	Cation eluent - 2.5 mm	Anion eluent - 3.2 mM Na2CO3 + l mM
Eluent		HNO3	NaHCO3
composition	Eluent B	Not defined	Not defined
	Eluent C	Not defiSned	Not defined
Flow		0.900 mL/min	0.700 mL/min
Pressure		5.91 Mpa	10.29 Mpa

Table 2. Concentration of major ions in Gharana Wetland.

	Winter 2012						Summer 2012					
Site	I	II	III	IV	V	VI	I	II	III	IV	V	VI
F^-	0.38	0.44	0.51	0.48	0.42	0.49	0.19	0.18	0.19	0.15	0.11	0.13
Cl^-	16.25	7.47	7.08	7.22	11.98	7.43	9.85	9.14	6.75	7.10	9.20	6.96
NO_3^-	bdl	bdl	bdl	bdl	bdl	bdl	2.45	2.59	2.29	1.95	1.23	2.61
SO_4^{2-}	38.30	36.24	33.82	33.34	33.25	32.01	21.99	17.99	19.38	20.86	29.09	21.26
PO_4^{2-}	bdl	bdl	bdl	bdl	bdl	bdl	3.32	3.27	2.85	3.14	2.51	2.18
HCO_3^-	nd	nd	nd	nd	nd	nd	175.06	155.61	151.72	145.89	130.33	132.27
Na^+	13.48	10.21	14.56	11.54	14.96	12.54	17.01	11.83	11.57	11.57	10.85	11.07
Ca^{2+}	97.51	83.64	79.99	87.85	95.43	88.98	55.94	43.58	39.33	51.38	39.97	47.27
K^+	36.44	12.65	8.96	12.97	23.45	14.05	36.35	18.72	30.01	26.99	19.62	24.15
Mg^+	28.33	22.79	26.63	24.73	27.83	25.71	11.31	8.62	6.90	7.53	4.48	7.53
Hardness	359.93	302.54	309.16	321.02	352.68	327.86	186.22	144.29	126.62	159.32	118.29	149.05

Table 1. Continued.

	Monsoon 2013					
Site	I	II	III	IV	V	VI
F^-	2.10	0.28	1.20	1.30	0.18	0.96
Cl^-	17.80	10.30	13.60	8.60	9.89	9.20
NO_3^-	4.10	4.20	3.70	1.50	3.16	2.10
SO_4^{2-}	26.40	22.98	24.30	19.60	18.98	23.10
PO_4^{2-}	6.18	1.92	2.60	3.30	2.39	2.90
HCO_3^-	254.20	119.10	121.10	127.10	142.89	148.90
Na^+	28.90	19.30	16.70	17.90	20.30	18.70
Ca_2^+	86.50	62.43	73.23	53.20	61.45	64.70
K^+	88.10	63.70	66.40	58.90	61.34	68.30
Mg^+	56.70	46.80	39.80	37.50	34.76	42.50
Hardness	448.72	347.96	346.26	286.75	296.14	336.00

in the water bordies.

The pH variations in water control the weathering pattern and availability of dissolved solids (Anshumali and Ramanathan 2007). The pH varied slightly acidic from 6.4 in winter to 7.4 and 7.5 in summer and monsoon season respectively. pH values of 8.8 were reported from the Mansar lake in Jammu (Salathia and Dutta 2013) and between 8.7 to 7.1 from high altitude Wular Lake in Kashmir (Khaliq et al. 2012, Rashid et al. 2013). Likewise, fluoride varied from 0.38-0.51 mg/l in winter, 0.11-0.19 mg/l in summer and 0.18-2.10 mg/l in monsoon. Fluoride concentrations in the natural waters vary with the type of rock through which the water flows. Fluoride concentration exceeded prescribed limit by WHO (1.5 mg/l) and BIS (1 mg/l) at some of the sites during monsoon season. Site 1 located close to the entry of village drain showed the highest concentrations. The monsoon maxima may be due to (i) leaching of fluoride pesticides from the agricultural fields and surface runoff, inflow from sewage, fecal matter and other solid waste (Masuda 1964, Dutt et al. 2011). Lower concentrations of the fluorides during the summer and the winter summer may be due to uptake by the lush growth of aquatic plants also by the animals. Fluoride concentrations are higher compared to those reported from Mansar Lake in Jammu, ranging from 0.028 to 0.076 mg/l (Dutt et al. 2011). Likewise, chloride concentrations ranged from 7.08-16.25 mg/l in winter, 6.75-9.85 mg/l in summer and 8.6-17.8 mg/l during monsoon which are lower than limits prescribed by BIS (2012) which is 250 mg/l. The chlorides enter surface water from dissolution of rocks, agricultural runoff, sewage and industrial discharges, urban, runoff oil well waste, effluent from wastewater treatment plants and salting road (Brezonik and Arnold 2011). Monsoonal precipitation also adds to the sea-salt

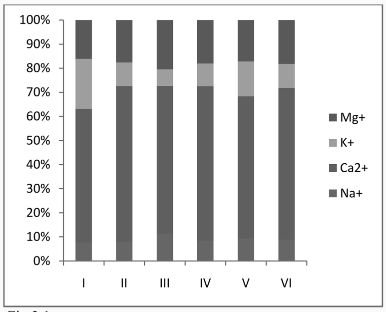
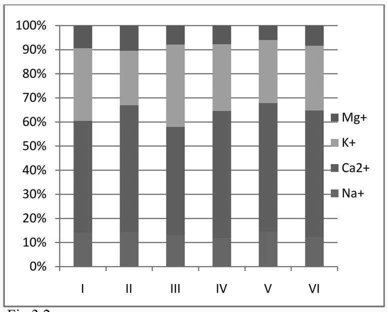


Fig.3.1



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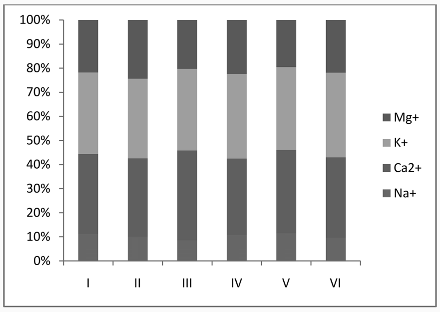

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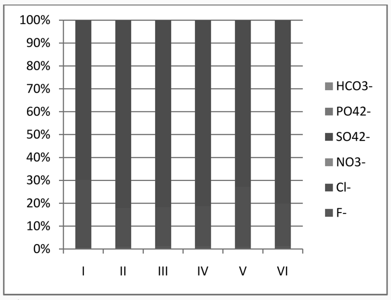

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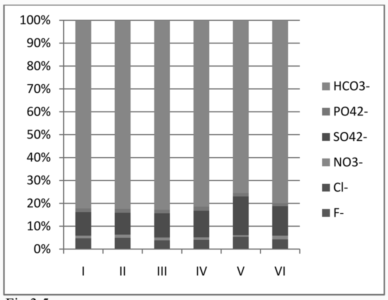

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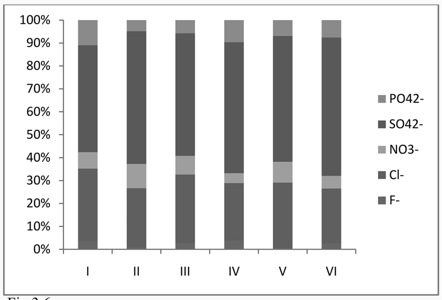

Fig.3.6

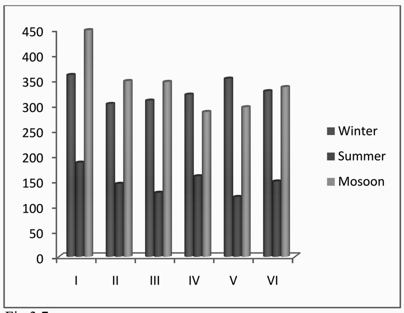

Fig.3.7

Fig. 3.1. Percentage fraction of cations in Winter at various sites. **Fig. 3.2.** Percentage fraction of cations in Summer at various sites. **Fig. 3.3.** Percentage fraction of cations in Monsoon at various sites. **Fig. 3.4.** Percentage fraction of anions in Winter at various sites. **Fig. 3.5.** Percentage fraction of anions in Summer at various sites. **Fig. 3.6.** Percentage fraction of anions in Monsoon at various sites. **Fig. 3.7.** Hardness (mg/l) of water at various sites in various season.

derived chloride. Chloride present in excess of 250 mg/l, imparts salty taste to water. In comparison, very lower concentrations of chloride were reported from the Himalayan Lakes in Spiti valley (Das and Dhiman 2003) and Pandoh Lake (Anshumali and Ramanathan 2007) in Himachal Pradesh.

Nitrate (NO^{3-}) is an important plant nutrient found naturally in the environment. Its main sources in surface waters are agricultural runoffs, sewage water containing human and animal wastes. Atmospheric precipitations also add nitrates in water. WHO recommends a concentration of 50 mg/l in water whereas, BIS recommends 45 mg/l of NO^3 in drinking water. NO^3 renged from 1.23-2.61 mg/l in the summer, 1.5-4.2 mg/l in the monsoon. In comparison, the nitrates values reported here are higher than mean values to be around 0.083 mg/l reported from the Nainital Lake (Gupta et al. 2008).

Sulfate varied from 32.01-38.3 mg/l in winter, 17.99-29.09 mg/l in summer and 18.98-26.4 mg/l in monsoon. Sulfates are discharged into the surface water from industries that use sulfates and sulfuric acid including mining and smelting operations, kraft pulp and paper mills, textile mills and tanneries (WHO 2012). Acid rain produced from burning of fossil fuel is also a major source sulfates in water. Sulfate fertilizers are another major source of sulfate to ambient waters. Oxidation of sulfur compounds in the lake bottom sediments at the boundary layers between aerobic and anaerobic environments also adds sulfates to the water (Anshumali and Ramanathan 2007). BIS has prescribed a concentration of 200 mg/l as desirable limit and 400 as maximum permissible limit in the drinking water. Sulfates present above 250 mg/l impart bitter taste to water. In comparison, the sulfate concentrations reported here are higher than those reported by Anshumali and Ramanathan (2007) in the Pandoh Lake, Mandi District, Himachal Pradesh.

Phosphates ranged from 2.18-3.32 mg/l in summer and 1.91-6.18 mg/l in monsoon. High amounts of phosphates are contributed agricultural runoff, sewage effluents, disposal of solid waste and decomposition of organic matter are other possible sources of PO_3.The relatively lower concentration nitrates and phosphates in monsoon and summer seasons may be due to their uptake by phytoplankton. Phosphates concentrations of 0.5-4.5 mg/l (Das and Kaur 2001) and 1.5-15.5 mg/l (Al-Mikhlafi et al. 2003) were reported in studied carried elsewhere.

The Gharana wetland is enriched with HCO^3 in all the seasons, with concentration ranged from 130.33-175.06 mg/l in summer and 119.10-254.20 mg/l in monsoon season. The HCO^{3-} in water is mainly contributed from weathering reactions and decomposition of organic matter occurring in the catchment area (Choudhary et al. 2009).

Among the cations, sodium is found in many minerals e.g. sodium chloride, amphibole, cryolite, soda niter and zeolite. Na ranged from 10.21 mg/l-14.96 mg/l in winter, 10.85-17.01 mg/l in summer and 16.7-28.9 mg/l in the monsoon. Sodium concentrations vary considerably depending on regional and local hydrological and geological conditions, the time of year. Most animals can tolerate relatively large doses by increasing NA^+ excretion. Al-Mikhlafi et al. (2003) reported similar values of Na^+ ranging between 9.44 to 11.80 mg/l, likewise, Das and Kaur (2001) reported Na^+ concentrations ranging from 6.07 to 12.14 mg/l from Renuka Lake, Himachal Pradesh. Lower Na^+ concentrations in comparison were reported by Anshumali and Ramanathan (2007) in Pandoh Lake, Himachal Pradesh. Ca concentration ranged from 79.99-97.51 mg/l in winter, 39.33-55.94 mg/l in summer and 53.2-86.5 mg/l in monsoon which at some sites is higher than the concentrations recommended by BIS (75 mg/l as desirable and up-to a maximum of 200 mg/l). Weathering of carbonates is generally considered to be the major source of Ca^{2+} and Mg^{2+} in the lake water. Similar values Ca^2 of 17-165 mg/l were reported by Al-Mikhlafi et al. (2003) from Mansar Lake, however, lower Ca^{2+} values were reported from Pandoh Lake,Himachal Pradesh (Anshumali and Ramanathan 2007). K concentration ranged from 8.96-36.44 mg/l in winter, 18.72-36.35 mg/l in summer and 58.9-88.1 mg/l in the monsoon. Potassium is an important nutrient and naturally available from mineral like feldspar. Polluted waters are also an important source of the K^+ to the water bodies. In comparison, lower concentrations of K^+ (1.04–1.71 mg/l) were reported by Al-Mikhlafi et al. (2003) in the Mansar Lake. Magnesium can be introduced by the weathering minerals (dolomite and magnetite) and also from the fertilizer application and from cattle feed. In Gharana, the Mg concentration varied from 22.79-28.33 mg/l in winter, 4.48-11.31 mg/l in summer and 34.76-56.70 mg/l in the monsoon. The monsoonal K^+ concentrations at some site exceeded the permissible limits for Mg prescribed by BIS (30 mg/l) for drinking water. Al-Mikhlafi et al. (2003) observed similar magnesium concentrations in Mansar Lake. However, higher values ranging 44.50 to 80.80 mg/l were reported from the Renuka Lake (Das and Kaur 2001). Water hardness ranged from 299.41-359.92 mg/l in winter season, 116.69-186.22 mg/l in summer and 275.51-448.72 mg/l in monsoon Fig. 3.7.

The overall lake water chemistry suggests that the major ion concentration in the lake seasonally fluctuated with highest concentrations reported in the monsoon season. The higher dissolved solids in during the monsoon season may be attributed to the fact that increased rate of surface and agricultural runoff triggered after first monsoonal showers. The lower concentration in summers is due to the dilution effect of water. In general, canal fed by river are full of water due to snow melting. In winter, the flow is low in the canal due to unavailability of snow melt water. Moreover, in winter since there is lower demand for irrigation water therefore, lower water is in the canal. The increased concentration of dissolved ion during the monsoon season may be attributed to the fact that during the monsoon season lot of dissolved material enter into the wetland through agricultural and surface runoff. Though to lesser extent, the contribution of precipitation to overall dissolved load also cannot be neglected.

The water quality data indicates that the concentration of most of the dissolved ions is maximum at the site 1.This is due to the domestic waste coming through overland flow at this location. Site 5 also shows concentrations that are generally higher compared to other sites except site 1. As mentioned earlier, site 5 refers to the near inflow location. All other sites such as site 2, site 3, site 4 and site 6 represent the locations either inside the wetland or near the outlet. The improved water quality at these locations exhibits that the wetland is carrying out its natural filtering function efficiently and due to the dilution effect.

Conclusion

Physico-chemical properties of Gharana wetland found to vary seasonally. The source of dissolved materials in the lake is primarily influenced by the weathering of rocks and the precipitation. Gharana wetland is mainly fed by the canal water derived from the river Chenab. Ferilizer rich irrigation water derived from canal as well as groundwater also find its entry into catch wetland influencing the concentrations of the dissolved materials. Concentration of major ions is more than reported by some other investigators.

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