Study on Physicochemical Characterization of
Konhaye Stream District Dir Lower, Khyber Pakhtunkhwa Pakistan

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Abstract: The present study was aimed to assess water quality of Konhaye stream District Dir Lower Khyber Pakhtunkhwa, Pakistan. For this purpose sampling was carried out from the stream and was analyzed for twenty two physical and chemical parameters. The results of the factors were compared with world health organization (WHO) standard and were correlated in between with Pearson correlation coefficient. Agricultural indices like Sodium Absorption Ratio (SAR), Sodium Percentage (Na %), Residual Sodium Carbonate (RSC), Kelley's Ratio (KR) and Soluble Sodium Percent (SSP) were also find out. The parameters studied were in varying ranges such as temperature: 19.9-27.9 ⊚, pH: 7.1-7.5, dissolved oxygen: 8.5-9.91 mg/L, electrical conductivity: 190.2-217.2 µs/cm, total dissolved solids: 111.1-135.12 ppm, total suspended solids: 120.9-134.4 ppm, free carbon dioxide: 110-131 ppm, turbidity: 67-81 NTU, salinity: 35-48 ppt, total hardness: 4.9-5.7 mg/L, calcium hardness: 2.3-3.8 mg/L, magnesium hardness: 93-117 mg/L, sodium: 11-19.7 mg/L, potassium: 0.001-0.041 mg/L, total alkalinity: 4.1-4.5 mg/L, chloride: 1.11-2.67 mg/L, nitrate: 0.001-0.11 mg/L, sulphates: 90-170 mg/L, CO_3: 10-40 mg/L, HCO_3: 25-100 mg/L and BOD: 0.2-12 mg/L. The obtained results showed that water quality of the stream lie within permissible limits suggested by WHO. It is also suitable for harboring a diversified fish fauna as it also lie in permissible ranges acquired for aquatic life as suggested by United State Public Health Standards (USPHS). The chemical indices SAR, Na%, RSC, KR and SSP classify the water quality as excellent for agricultural practices. To protect water quality, it should be assessed regularly. Agricultural run offs and domestic wastes should be treated properly before disposing off and waste materials should be dumped to suitable sites.

Key words: Konhaye Stream · Tributary · River Panjkora · Dir Lower · Dir Upper

INTRODUCTION

No one can under estimate the need and necessity of water for human life [1]. Water quality, as always, is of key interest of human beings as their welfare is directly related to it [2]. Most of the developmental activities are depending upon rivers, which make them most important freshwater resources [3]. Humans, animals especially aquatic and plants require water, which is moderately pure and free of chemicals and microbial contaminants [4].

They cannot survive if their water is loaded with toxic chemicals [5]. Even severe load of these contaminants kill all life forms [6, 7].

Water is must for men's existence as well as all other living things [8]. The riverine system is one of the most important resources of water supply in different regions of the world as it provides water for drinking as well as for agricultural, industrial and other purposes [9, 10]. The water is relatively pure, at the source but changes took place in its use, land use and hydrological conditions

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because of the abstractive water use, urban population growth, industrialization, agricultural activities such as chemicals use and household increase of chemicals [11]. Throughout the globe, water pollution is on increase which makes it one of the most debatable issues of the era [12]. Among the major goals of millennium development regarding healthy living of masses, is to provide them with safe and convenient water [13].

Pollution is the major issue echoing on horizon of environmental research. It is affecting every niche of biosphere. The aquatic ecosystem is also one of these affected environments [14]. It consists of several components that are directly as well as indirectly affected by pollution [15]. This pollution ultimately affects aquatic organisms, fish being standing first [16, 17]. On account of anthropogenic activities such as domestic wastes, untreated sewages and industrial and agricultural effluents, the main aquatic bodies are continuously deteriorating in Pakistan as well as all over the world [18]. The nutrient inputs are highest from towns and agricultural fields [19]. This problem increased dramatically since last few decades with advancement in industrialization and urbanization [20, 21]. This condition is even more deteriorated if these water supply sources pass on through cities or populated areas [22]. The contaminants get passed to water bodies from the everyday life activities of these masses and making water bodies as focal point of the pollution [23].

Water quality is assessed by evaluating its physical and chemical contents [24]. Changes take place in water quality even with seasons and geographic areas' change without any pollution being involved. Water quality guidelines deliver scientific information about water quality factors. It also provides ecologically relevant toxicological threshold values to protect specific water uses [25]. There are many vital physical and chemical factors that affect aquatic bodies [26]. These are temperature, pH, hardness, carbon dioxide, total solids and alkalinity etc. Water quality deterioration is contributed by pollutants and effluents from different sources such as agricultural runoffs, waste products dumping, detergents and household wastes etc. [27].

The present study was conducted in order to assess the water quality of Konhaye stream District Dir Khyber Pakhtunkhwa. Its water was assessed by studying its different physical and chemical parameters. The studied factors are temperature, pH, dissolved oxygen, electrical conductivity, total dissolved solids, total suspended solids, free carbon dioxide, turbidity, salinity, total hardness, calcium hardness, magnesium hardness, sodium, potassium, total alkalinity, chloride and nitrate.

MATERIALS AND METHODS

Sampling Area: District Dir Lower is situated with Longitudes and Latitudes of 34°, 37' to 35°, 07' North and 71°, 31' to 72°, 14' East respectively with approximate 2700 feet (820 meter) above mean sea level experiencing an annual rain fall of 1468.8mm and 253.7mm during December and March respectively [28]. District Dir is bounded by District Chitral to the Northern Side, by Bajaur and Afghanistan to the Western side, by District Malakand to the Southern side and by District Swat to Eastern side [29]. River Panjkora originates from Kohistan, District Dir (Upper) and flow southward dividing District Dir Upper and Lower into two halves. River Panjkora joins River Swat at Bosaq pull, Sharbatti (behind Totakan, District Malakand) [30]. The name Panjkora is because of the main five tributaries that fall in the River at four different places at District Dir Upper (Gwaldi Stream at Sheringal, Barawal Stream at Chukiatan, Usherai Dara Stream and Nurhund Stream at Darora and Dobando Stream at Akhagram) while two tributaries fall in the River at two different places in District Dir Lower (Konhaye Stream at Koto and Round Stream behind Thrai by pass near Timergara) [31]. Figure 1 is showing the study area.

Sampling and Data Analysis: Water samples were collected using sterilized polythene bottles, twice a month on every 15th and 30th, for four months by following Hassan *et al.* [32]. These bottles were first washed with tape water and were then rinsed using double deionized water. Water sampling was carried out from April through July 2013. The conductivity and pH were determined on the site, whereas the samples were transported to laboratory for further analysis.

Portable pH meter was used for measuring the pH of the water samples (Natner, UK). The conventional methods referred by American Public Health Association [33] were followed for determining total alkalinity, total suspended solids (TSS), total dissolved solids (TDS), total hardness, magnesium hardness, calcium hardness, chlorides and sulphate contents. Portable conductivity meter (Jenway, England) was used for finding conductivity. Sulphonilic method using UV Spectrophotometer (Hitachi-U-2000) was used for measuring Nitrite contents. For measuring Sodium and Potassium contents Flame Photometer (Jenway-FPF-7) was used. The colour, odour and taste of the water samples were detected organolaptically.
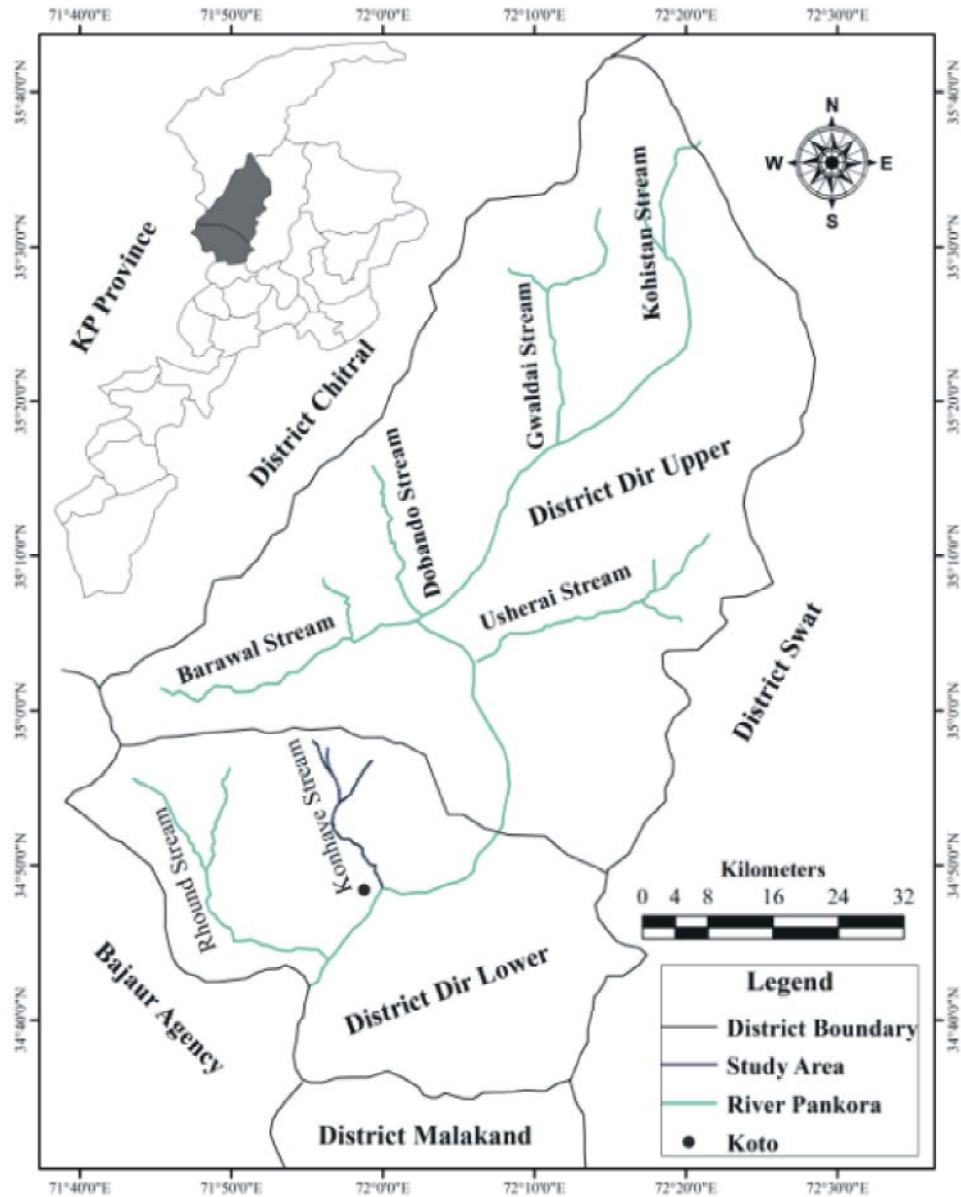
Fig. 1: District Dir Lower and Upper showing study area

Statistical Analysis: All statistical analysis, Mean, Standard deviation, Pearson Correlation Coefficient and Percentages, was performed using Microsoft Excel 2013. Arc GIS 9.3 Platform was used for preparing the map of the study area. Piper trilinear diagram for the studied cations and anions was prepared using GW_Chart Version 1.23.2.0 by following Manoj *et al.* [34]. The Agricultural indices, Sodium Absorption Ratio, Sodium Percentage and Residual Sodium Carbonate were calculated [35]. Kelley's Ratio and Soluble Sodium Percent were also calculated [8].

RESULTS AND DISCUSSION

The highest temperature (27.9°C) was recorded in July and the lowest (19.9°C) in April. Similarly the highest pH (7.5) was recorded in May and July and lowest (7.1) in June, the highest D.O (9.91 mg/L) was recorded in April and lowest (8.5 mg/L) in July, the highest EC (217.2 µs/cm) was recorded in July and lowest (190.2 µs/cm) in April, the highest TDS (135.04 mg/L) was recorded in July and lowest (111.1 mg/L) in April, the highest TSS (134.4 mg/L) was recorded in April and lowest (120.9 mg/L) in May, the

Table 1: Physicochemical parameters (mg/L) of the Konhaye Stream District Dir (L)

Parameters	April	May	June	July	Mean	S.D	Limits for aquatic life *
Temp (°C)	19.9	21.2	23.5	27.9	23.125	3.514	16-40°C
pH	7.23	7.5	7.1	7.5	7.3325	0.201	6.5-9.0
DO (mg/l)	9.91	8.9	8.7	8.5	9.0025	0.627	5.0
EC(μs/cm)	190.2	198.5	200.8	217.2	201.675	11.307	100
TDS (ppm)	111.1	123.12	135.04	135.12	126.095	11.477	<400
TSS (ppm)	134.4	120.9	131.5	121.6	127.1	6.864	<80
$FreeCO_{2(ppm)}$	130	128	110	131	124.75	9.912	10-15
$Turbidity_{(NTU)}$	79	67	79	81	76.5	6.403	0.5-10
Salinity (ppt)	39	35	47	48	42.25	6.291	0.001-0.5
T.H (mg/l)	4.9	5.2	5.1	5.7	5.225	0.34	10-400
Ca.H (mg/l)	2.3	2.5	3.8	3.3	2.975	0.699	4-160
Mg.H (mg/l)	93	99	111	117	105	10.954	<15
Na (mg/l)	11	17	18.5	19.7	16.55	3.861	>5
K (mg/l)	0.041	0.001	0.009	0.007	0.014	0.018	<5
T.A (mg/l)	4.3	4.1	4.4	4.5	4.325	0.171	10-400
Cl (mg/l)	1.11	1.34	2.18	2.67	1.825	0.727	10-600
NO_3 (mg/l)	0.001	0.001	0.1	0.11	0.053	0.0602	0.1
CO_3 (mg/l)	40	10	30	20	25	12.91	25
HCO_3 (mg/l)	80	25	40	100	61.25	34.731	100
SO_4 (mg/L)	110	130	90	170	125	34.156	≤ 500

* Limits suggested by the USPH for surface water [37]

highest Total hardness (131 mg/L) was recorded in July and lowest (110 mg/L) in June, the highest Free CO_2 (4.5 ppm) was recorded in July and lowest (4.1 ppm) in May, the highest Turbidity (2.67 NTU) was recorded in July and lowest (1.11 NTU) in April, the highest Salinity (0.11 ppm) was recorded in July and lowest (0.001 ppm) in April and May, the highest Calcium hardness (81 mg/L) was recorded in July and lowest (67 mg/L) in May, the highest Magnesium hardness (48 mg/L) was recorded in July and lowest (35 mg/L) in May, the highest Sodium (5.7 mg/L) was recorded in July and lowest (4.9 mg/L) in April, the highest Potassium (3.8 mg/L) was recorded in June and lowest (2.3 mg/L) in April, the highest Total Alkalinity (117 mg/L) was recorded in July and lowest (93 mg/L) in April, the highest Chloride (19.7 mg/L) was recorded in July and lowest (11 mg/L) in April and the highest Nitrate (0.045 mg/L) was recorded in April and lowest (0.001 mg/L) in May. All the above mentioned water quality parameters were observed as they influence the aquatic biota diversity. Detailed descriptions of these parameters are given in Table 1.

The strongest correlations (r > 0.5, p = 0.001) with Temperature across all sampling sites included EC, Turbidity and Total alkalinity 0.981, 0.966 and 0.951 respectively, with pH was shown by Total hardness followed by Sodium 0.7516 and 0.6727 respectively, with DO by Nitrate (r = 0.913) and TSS (r = 0.674), with EC by Sodium, Turbidity and Total alkalinity 0.9781, 0.9143 and 0.9091 respectively, with TDS by Chlorine (r = 0.9609) and Total alkalinity (r = 0.9538), with TSS by Nitrate (r = 0.7941), with Calcium hardness by Free CO_2 (r = 0.93)

and Magnesium hardness (r = 0.815), with Magnesium hardness by Salinity (r = 0.966),, Free CO_2 (r = 0.954) and Turbidity (r = 0.902), with Sodium by turbidity (r = 0.805), with Potassium by Salinity (r = 0.927),with Total alkalinity by Turbidity (r = 0.994) and Salinity (r = 0.962), with Chlorine by Turbidity (r = 0.843), with Free CO_2 by Salinity (r = 0.859) and with Turbidity highest correlation was shown by Salinity (r = 0.969). Table 2 is showing Pearson correlation coefficient matrix.

The physicochemical characteristics provide a fair idea of water quality of any source of water. The results of the studied water parameters showed variation between different ranges. The water quality parameters were observed and the results for most of the areas showed its fitness for human consumption. Most of water quality parameters were within the permissible limits when compared with suggested permissible limits of WHO [36] for human consumptions, rendering it fit for drinking purpose. When compared against the standards of [37], the water quality was falling within permissible limit for aquatic life, rendering it suitable for harbouring fish fauna.

Dissolved oxygen (DO) is the amount of oxygen dissolved contained by the water. It is among those vital water parameters which play a key role for supporting aquatic life. Most of the times high community respiration and organic matter decomposition leads to oxygen depletion. That's why DO content of any aquatic body has been extensively used as a parameter delineating water quality. It is also used to evaluate the degree of freshness of any water body [38].

Table 2: Correlation coefficient matrix of the studied physico-chemical parameters of the water of Konhaye Stream

	Temp	pH	DO	EC	TDS	TSS	TH	Ca. H	Mg. H	Na	K	T.A	Cl	NO$_3$	F. CO$_2$	Turb.	Salinity
Temp	1																
pH	0.341	1															
DO	-0.79	-0.329	1														
EC	0.981	0.5069	-0.829	1													
TDS	0.831	0.0682	-0.952	0.806	1												
TSS	-0.5	-0.903	0.674	-0.659	-0.429	1											
TH	0.011	0.7516	0.309	0.1171	-0.48	-0.397	1										
Ca. H	0.484	-0.435	0.019	0.3184	0.2438	0.4808	-0.139	1									
Mg. H	0.809	-0.27	-0.552	0.6814	0.7602	0.081	-0.4	0.815	1								
Na	0.925	0.6727	-0.771	0.9781	0.6926	-0.768	0.2989	0.191	0.525	1							
K	0.672	-0.351	-0.743	0.5723	0.9072	-0.01	-0.732	0.473	0.865	0.396	1						
T.A	0.951	0.1274	-0.88	0.9091	0.9538	-0.399	-0.295	0.456	0.871	0.805	0.861	1					
Cl	0.806	0.3093	-0.999	0.8357	0.9609	-0.655	-0.32	0.012	0.578	0.772	0.761	0.894	1				
NO$_3$	-0.51	-0.458	0.913	-0.611	-0.765	0.7941	0.2421	0.425	-0.17	-0.61	-0.49	-0.61	-0.9	1			
F. CO$_2$	0.765	-0.226	-0.343	0.6305	0.5603	0.1649	-0.172	0.93	0.954	0.502	0.677	0.748	0.372	0.0705	1		
Turb.	0.966	0.1167	-0.827	0.9143	0.9172	-0.354	-0.244	0.538	0.902	0.81	0.839	0.994	0.843	-0.527	0.809	1	
Salinity	0.879	-0.131	-0.749	0.7865	0.9021	-0.132	-0.435	0.638	0.966	0.641	0.927	0.962	0.769	-0.419	0.859	0.969	1

Bold r-Values >0.500 are significant at p < 0.05.

Temp=Temperature, DO=Dissolved Oxygen, EC=Electric Conductivity, TDS=Total Dissolved Solids, TSS=Total Suspended Solids, TH=Total hardness, Ca. H= Calcium hardness, Mg. H=Magnesium hardness, Na=Sodium, K=Potassium, T.A=Total Alkalinity, Cl=Chloride, NO$_3$=Nitrate, F.CO$_2$=Free Carbon dioxide, Turb.=Turbidity.

Table 3: Agricultural indices (SAR, Na% and RSC) showing respective Sodium Hazard Classes (SHC)

	Sodium Absorption Ratio		Sodium Percentage		Residual Sodium Carbonate	
Months	SAR Value	Water Class	Na % Value	Water Class	RSC Value	Water Class
April	1.594	Excellent	10.383	Excellent	24.7	Unsuitable
May	2.386	Excellent	14.347	Excellent	-66.5	Good
June	2.442	Excellent	13.884	Excellent	-44.8	Good
July	2.540	Excellent	14.076	Excellent	-0.3	Good
Mean	2.252	Excellent	13.301	Excellent	-21.725	Good

Table 4: Agricultural indices (KR and SSP) showing respective Sodium Hazard Classes (SHC)

	Kelley's Ratio		Soluble Sodium Percent	
Months	KR Value	Water Class	SSP Value	Water Class
April	0.115	Suitable	10.348	Good
May	0.167	Suitable	14.346	Good
June	0.161	Suitable	13.878	Good
July	0.164	Suitable	14.071	Good
Mean	0.153	Suitable	13.291	Good

Biological oxygen demand (BOD) is a measure of oxygen. Microorganisms require BOD for decomposition of organic matter present in the water. This biodegradation exerts oxygen tension and elevate the biochemical oxygen demand [39]. It directly affects the amount of dissolved oxygen. It simply means greater the BOD content, the more rapidly, it will result in oxygen depletion. This ultimately results into low oxygen availability for aquatic organisms and can lead to their death. The observed BOD for the month of April was 0.5 mg/L, for May was 0.7, for June was 0.9 and for July was 1.2 mg/L. The increasing trend in BOD from April to July may be due to increasing trend in metabolic activities of microbes present in the water bodies and low decomposition rate of organic matter [40].

Chemical Oxygen Demand (COD) is the main parameter to assess the quality of wastewater because it shows the amount of oxygen required to destroy both inorganic and organic matters contained by the effluents. In water there is no standard mentioned, it means the entire water source should be COD free [9]. None of sample in our study was having COD value.

The pH value of water source is a measure of the hydrogen ion concentration in water and indicates whether the water is acidic or alkalinity [41]. The pH of water is a major parameter because all biochemical and chemical reactions are governed by it. pH range is significant for the biotic communities as most of the plants and animals can survive in a narrow range only such as from slightly acidic to slightly alkaline condition

[42]. pH of an aquatic body is basically the measure of its acid base equilibrium, achieved by various dissolved compounds. Almost in most natural water bodies pH is controlled by CO_2-HCO_3 equilibrium system. pH beyond the permissible limit damages the mucous membrane of the cells [43]. In our study pH was within the permissible limits and there was no alarming situation across all sampling months.

Electrical conductivity (EC) provides an idea of the total solids contained by the water or it is the measure of the ability of water to conduct electrical current. This capacity of conductance depends upon ions concentration, valence of ions, ionic mobility and temperature of the water. EC of water is a direct function of its total dissolved salts [44].

Total dissolved solids (TDS) are the total amount of moving charged particles which are dissolved in a given volume of the water. TDS in water is due to the occurrence of all organic and inorganic substances. These may be iron, magnesium, calcium, sodium, potassium, carbonates, manganese, phosphates, chlorides, bicarbonates and other minerals. TDS higher than permissible limits cause gastrointestinal irritation to the human beings. Long-time use of water having high TDS can lead to kidney stones and heart diseases [45].

Total hardness is an aesthetic quality of water. It is caused by sulphates, carbonates, bicarbonates and chlorides of calcium and magnesium. Its presence in higher amount prevents lather formation with soap. It also elevates the boiling point of water. Water having hardness up to 75mg/L is normally classified as soft, 76-150 mg/L is considered moderately soft, 151-300 mg/L as hard while more than 300 is considered as very hard. Very hard water can cause heart and kidney problems, if continuously used [46]. Hardness indicates the concentration of calcium and magnesium ions contain by the water body. Calcium in water is often consequence of leaching from rocks; lime stone and industrial waste. Calcium is significant for proper bone growth.

Chloride is an indicator of pollution by sewage, as if higher than the normal values or permissible limits showing pollution [2]. Industrial effluents and domestic wastes cause elevation in chloride content of water. Soil porosity and permeability also has a key role in building up the chloride concentration [47]. Chloride higher than the permissible limits harms agricultural crops and metallic pipes. It also effect human health and can cause heart and kidney diseases [48].

Nitrate (NO_3) level in water is used to find out self-purification property of the water bodies. Decaying plants and animals are the main sources of nitrate in water body [49]. The nitrate values of our investigation were falling within the standard permissible limit suggested [50].

Potassium (K^+) is an essential element for humans, animals and plants and is derived mainly from vegetation and soil in food chain. The main sources of potassium in ground water include weathering of potash silicate minerals, use of potash fertilizers, rain water and use of surface water for irrigation. Although potassium is widely found in some of the igneous and sedimentary rocks yet its concentration in natural waters is generally pretty low. This is due to the fact that potassium minerals offer resistance to weathering and dissolution [8].

Some major ions determined in water samples were plotted on the Piper trilinear diagram and compared with other reported literature in order to classify and designate ionic nature of water [51]. This illustration of ionic signature helps in uncovering the principal ions controlling the water chemistry. The classification scheme of the studied parameters is given in Figure 2. The Piper diagram classified all water samples into 'Mixed Ca^{2+}-Na^+-HCO_3^- Type'. Classification of water types is displayed in Figure 3. No change in water types was recorded temporally suggesting the ionic stability of water bodies with respect to Na^+, K^+, Ca^{2+}, Mg^{2+}, HCO^{3-}, Cl^- and $SO4^{2-}$ [34].

Water employed for irrigation is an imperative factor in crop productivity, its yield and quality of the irrigated crops. The irrigation water quality primarily depends upon the occurrence of dissolved salts and their concentrations. Sodium Absorption Ratio (SAR) and Residual Sodium Carbonate (RSC) are the most important quality criteria, which influence the water quality and its suitability for irrigation. The suitability of the groundwater for irrigation purpose was determined on the basis of Sodium Absorption Ratio (SAR), Sodium Percentage (Na %) and Residual Sodium Carbonate (RSC) [35]. Kelley's ratio and Soluble Sodium Percent were also calculated [8].

SAR is used to find out the suitability of water for irrigation as it gives a measure of alkali/sodium hazard to crops. The sodium/alkali hazard is typically expressed as SAR [52]. If SAR value range <10 then its excellent, if fall within 10-18 then good, if 18-26 then doubtful and if >26 then its unsuitable for agriculture. SAR values were varying in the range of 1.594 to 2.54, which indicates that all water samples fall in S1 hazard class, means excellent for agriculture.
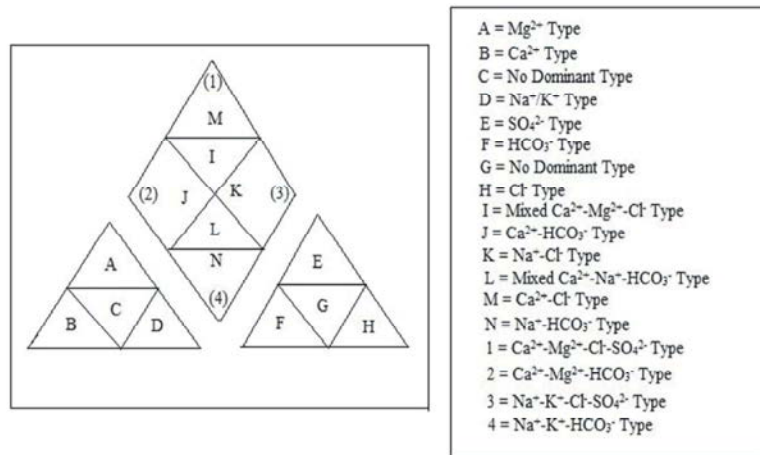
A = Mg^{2+} Type
B = Ca^{2+} Type
C = No Dominant Type
D = Na$^+$/K$^+$ Type
E = SO$_4^{2-}$ Type
F = HCO$_3^-$ Type
G = No Dominant Type
H = Cl$^-$ Type
I = Mixed Ca^{2+}-Mg^{2+}-Cl$^-$ Type
J = Ca^{2+}-HCO$_3^-$ Type
K = Na$^+$-Cl$^-$ Type
L = Mixed Ca^{2+}-Na$^+$-HCO$_3^-$ Type
M = Ca^{2+}-Cl$^-$ Type
N = Na$^+$-HCO$_3^-$ Type
1 = Ca^{2+}-Mg^{2+}-Cl$^-$-SO$_4^{2-}$ Type
2 = Ca^{2+}-Mg^{2+}-HCO$_3^-$ Type
3 = Na$^+$-K$^+$-Cl$^-$-SO$_4^{2-}$ Type
4 = Na$^+$-K$^+$-HCO$_3^-$ Type

Fig. 2: Reference Piper trilinear diagram; Left and right triangles designate cations and anions respectively (modified from elsewhere) [51]
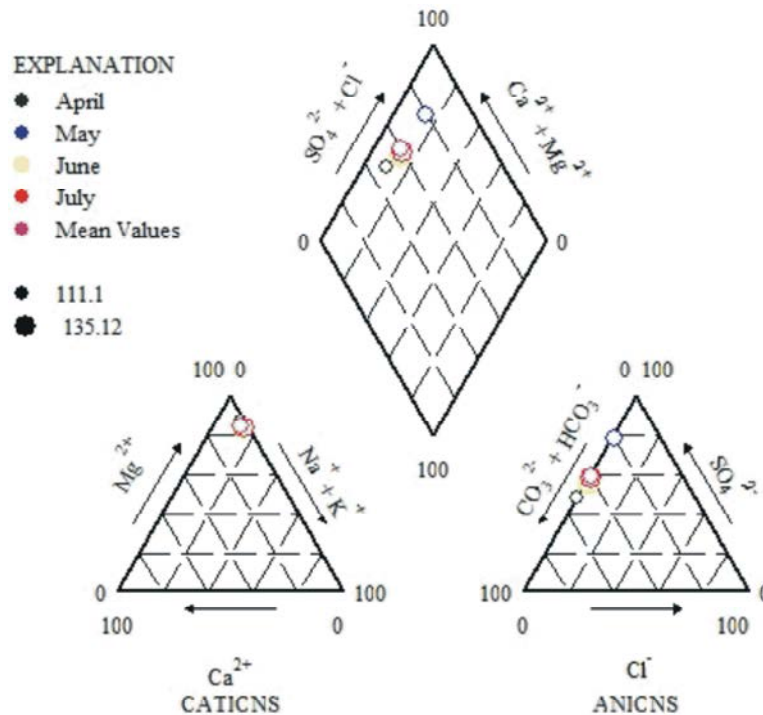
Fig. 3: Piper trilinear diagram illustrating hydrochemical regime across four months

Doneen method is used for calculating Na %. The concentrations are expressed in epm [53]. If Na % value <20% then it is reflecting excellent category, if it is 20-40% then it is good category, if 40-60% then it is permissible category and if 60-80% then it is doubtful class [54]. Na % values were falling in the range of 10.383 to 14.347, which reflect that the water is excellent for agricultural practices.

RSC gives an account of Calcium and Magnesium in water sample as compared to carbonates and bicarbonates ions. RSC value is less than 1.25 indicates low hazard,

value of 1.25-2.5 indicates medium hazard while more than 2.5 indicates high hazard to crop growth [55]. RSC for the month of April is quite higher than normal range which is not suitable for agriculture. For remaining water samples, from May to July were falling were good for agricultural purposes.

Sodium measured against Ca^{2+} and Mg^{2+} is used to calculate Kelley's ratio [56]. A Kelley's Ratio (KR) of more than one indicates an excess level of sodium in waters. Hence, waters with a Kelley's Ratio less than one are

suitable for irrigation, while those with a ratio more than one are unsuitable for irrigation [8]. In our study all of the sampling months were having ratio less than one, which means the water of Konhaye stream is suitable for agriculture.

Soluble Sodium Percent (SSP) was also calculated. SSP is expressed in milliequivalents per liter (epm). The Soluble Sodium Percent (SSP) values less than 50 or equal to 50 indicates good quality water and if it is more than 50 indicates the unsuitable water quality for irrigation [8]. In our study all of the sampling months were having SSP value less than 50, which indicates that the water is good for agricultural purposes.

All the agricultural indices are showing that the water of the stream is excellent for agricultural practices and can be utilized for improving the deteriorated agricultural conditions of the area. The results for SAR, Na% and RSC along with Sodium Hazard Classes (SHC) are given in Table 3. KR and SSP are given in Table 4 with their SHC.

CONCLUSION

The study showed that the water quality of the Konhaye stream lie within optimum range as suggested by WHO for drinking and is utilizable for drinking. While comparing against the standards provided by USPHS, its water is potential of harbouring fish fauna. This stream can be used to mitigate with the over exploited nearby water bodies. If proper stocking is done in future, in a planned way by Fisheries Department, the stream could harbour more diversity and greater number of fish. The agricultural indices Sodium Absorption Ratio, Sodium Percentage and Residual Sodium Carbonate were also classifying the water quality as excellent for agricultural practices, means the water of the stream can be utilized for elevating agricultural practices and quality of crop production in the nearby area. Owing to these two factors, if properly managed, this stream can be the backbone of economy for the local masses.

Recommendations: To maintain the water quality, all polluting anthropogenic activities should be controlled. Water quality should be assessed regularly. Mass awareness programs should be initiated to educate local people about water scarcity, pollution and conserving water quality. Water filters must be installed and old pipes should be replaced in order to control water borne diseases. Wastes from houses and industrial and agricultural run offs should be treated before entering the streams and other tributaries.

Disclosure: None of the authors have any conflict of interest.

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