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Physicochemical Properties of Soil and Water Along Haro River and Khanpur Dam, Haripur, Pakistan

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Abstract: This study was conducted along the Haro River and Khanpur dam in southern Haripur Tehsil to evaluate the physio-chemical properties of soil and water to determine its agricultural suitability and to demonstrate the effectiveness of GIS techniques for this analysis. There were 42 samples (20 of soil and 22 of water) collected along the Haro River and Khanpur dam in autumn season after rain. ArcGIS 9.3 software and 3D Analyst extension were used to interpolate the collected samples. It was found that water pH was in the range of 6.94 to 8.11 while EC dsm-1 was from 0.19 to 0.41 which was within the normal range having no salinity and sodicity hazard. Water is fit for irrigation. Soil data showed that pH was in the range of 7.2 to 8.32 and EC dsm-1 in the range of 0.04 to 1.166, while soil texture was sandy clay loam to sand type. Whereas all the soil in study area was mostly calcareous. Organic matter was deficit in most of the soil samples. It was found that the remote sensing, GIS and GPS survey techniques were also very useful to identify and analyze the trends of soil and water parameters.

Keywords: Agriculture**,** pH, electrical conductivity, physico-chemical, GPS, remote sensing, GIS.

Introduction

The whole world depends on water. Clean water is a vital natural resource for industry, agriculture, and for the production of energy (www.wri.org/our-work/topics/water). Water is important for agricultural activities. Rivers, springs and lakes are sources of water for irrigation which are facing the problems of pollution. (Wimbaningrum, et al., 2013).Water quality depends upon the reflection of physical, chemical and biological constituents that are dissolved in water. Human activities and natural processes contribute to these constituents. Natural factors i.e. geology, topography, wildlife, soils, vegetation, climate and population influence the water quality (Committee on Watershed Management, National Research Council, 1999).

The selected area for this research study is southern Haripur Tehsil which covers 867 sq.km area. The west to east extent of study area was 72.547595°E (DMS:72° 32′ 51.34″E) to 73.22°E (DMS:73° 13′ 13.75″E) and south to north extent was 33.716569°N(33° 42′ 59.65″N) to 34.440°N(34° 26′ 25.66″N). The study area, southern Haripur is bounded by Northern Haripur Tehsil towards the north, by Abbottabad toward the east, by Islamabad capital city to the south(Figure 1).

A study was conducted on the catchment of Soan River located in Rawalpindi/Islamabad to evaluate the physico-chemical and bacteriological status. Arc GIS 9.3 software was used to show the spatial variability and locations of soil and water samples. 3D Analyst extension was used to show the altitude interval for highlighting the altitudinal effects on sample's parameters. It was found after testing the physico-chemical and bacteriological parameters that present situation of the Soan River (especially in Zone 1) water was not suitable for humans as well as aquatic lives of this river. The sources of bacteriological parameters were total coliform and fecal coliform (Jalil and Khan, 2014).

Materials and Methods

In this paper it was focused to assess the physicochemical properties and fertility status of different soil and water samples of the study area. Primary and secondary data sources were used during this study. Arc GIS 9.3 software product of ESRI (Environmental System Research Institute) with its 3D Analyst extension was used for interpolation of soil and water quality analysis and methodology given in Figure 2 was followed.

A field visit was conducted for this study during September 2014. Soil and water samples were collected along the Haro River, Khanpur dam, small dams (Rehana dam, Kahal dam andMang dam) as a primary data source. GPS (Global Positioning System) locations (latitude, longitude, elevations above mean sea level) of all the samples were also taken with Garmin GPS receiver Etrex.

In secondary data source a topo map, soil map and a union council of Haripur district were used to extract the boundary of study area comprising 22 union councils of Haripur Tehsil located in southern Haripur Tehsil.

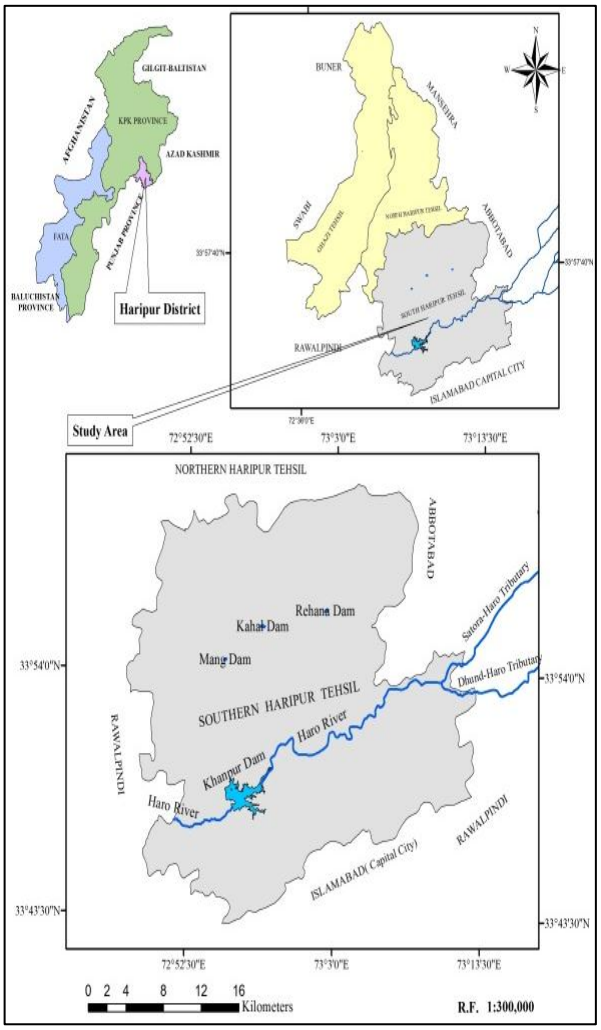


Fig. 1 Location map of study area.

The upper layer of soil was thoroughly mixed by hand air dried, and kept in well stoppered polyethylene bags having capacity 500grams and numbered according to the planned field codes. On the other side, water samples were collected from streams and nullahs (drains) contributing to the main river of study area named, Haro River, Khanpur dam, and small dams (Rehana dam, Kahal dam and Mang dam).Water samples were taken exactly near the same location from where soil samples were taken. Clean plastic bottles were used for water sampling and coded accordingly. All collected samples of water and soil were tested in the laboratory of Centre for Integrated Mountain Research, University of the Punjab, Lahore. The pH of soil and water was tested by using turbidity meter and their EC was checked by using electrical conductivity meter and RSC (Residual Sodium Carbonate) of 22 water samples was calculated by using following formula:

$$RSC = (CO_3+HCO_3) - (Ca+Mg)$$

According to a study (Rashidi and Seilsepour, 2011) Sodium Adsorption Ratio of all soil samples was calculated by using following formula:

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

Calcium carbonate of all soil samples was analyzed by pouring HCL (Hydrochloric acid on all soil samples) and soil texture of soils was analyzed by sieve analysis technique.

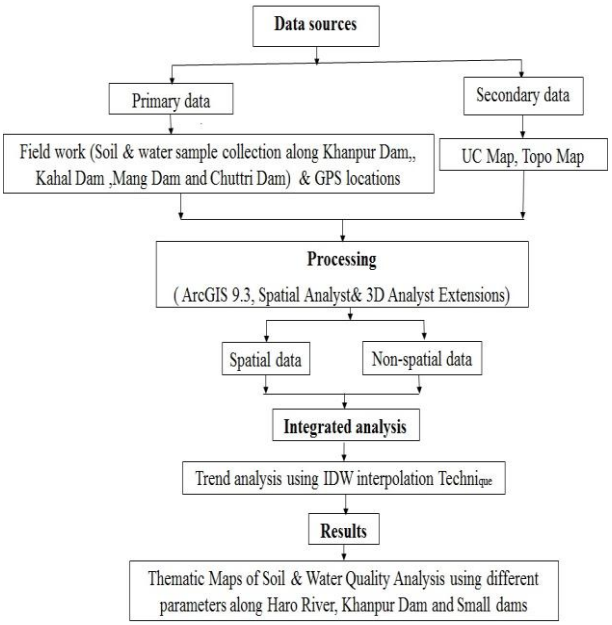


Fig. 2 Flow diagram.

GPS data collection of water and soil samples

The spatial locations of collected samples of soil and water along Haro River, Khanpur dam and small dams (Rehana dam, Kahal dam and Mang dam) were added into ArcMap, a component of ArcGIS software 9.3 by connecting GPS receiver Etrex.

Assessment of physico-chemical properties of water

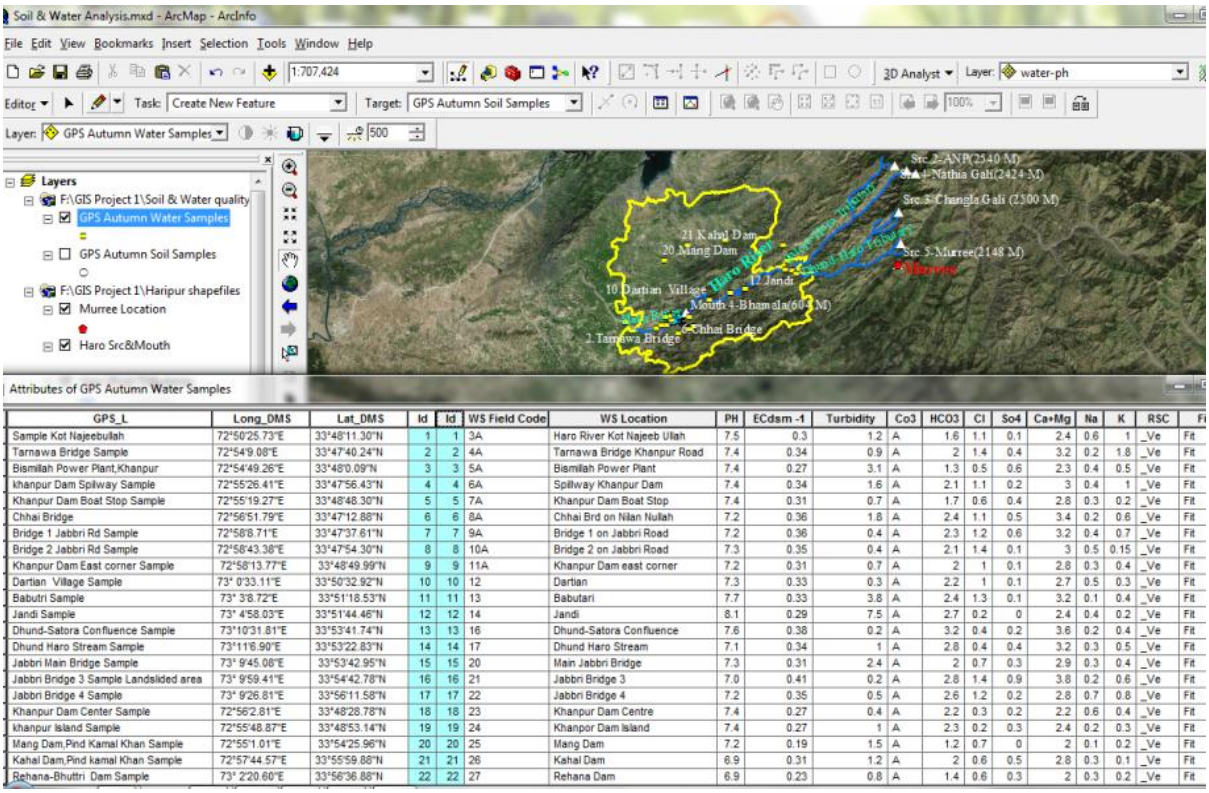
The parameters i.e. pH, EC, Turbidity, CO_3, HCO_3, Cl, SO_4, Ca+Mg, Na, K and RSC of water samples were assessed in the lab and an Excel sheet of all the parameters was prepared. Assessed physio-chemical properties of water samples were impolated to Arc Map and spatial locations (spatial data) and physio-chemical parameters (non-spatial data) were integrated into Arc GIS by using their unique field of Id as shown in Figure 3. Water pH, EC, Turbidity, CO_3, HCO_3, Cl, SO_4, Ca+Mg, Na and K were interpolated in Arc GIS by using GIS technique of interpolation named IDW (Inverse Distance Weighted).

Physicochemical properties of soil

GPS locations of soil samples collected along Haro River, Khanpur, Rehana, Kahal and Mang dams were shown in Table 1 and Figure 4.

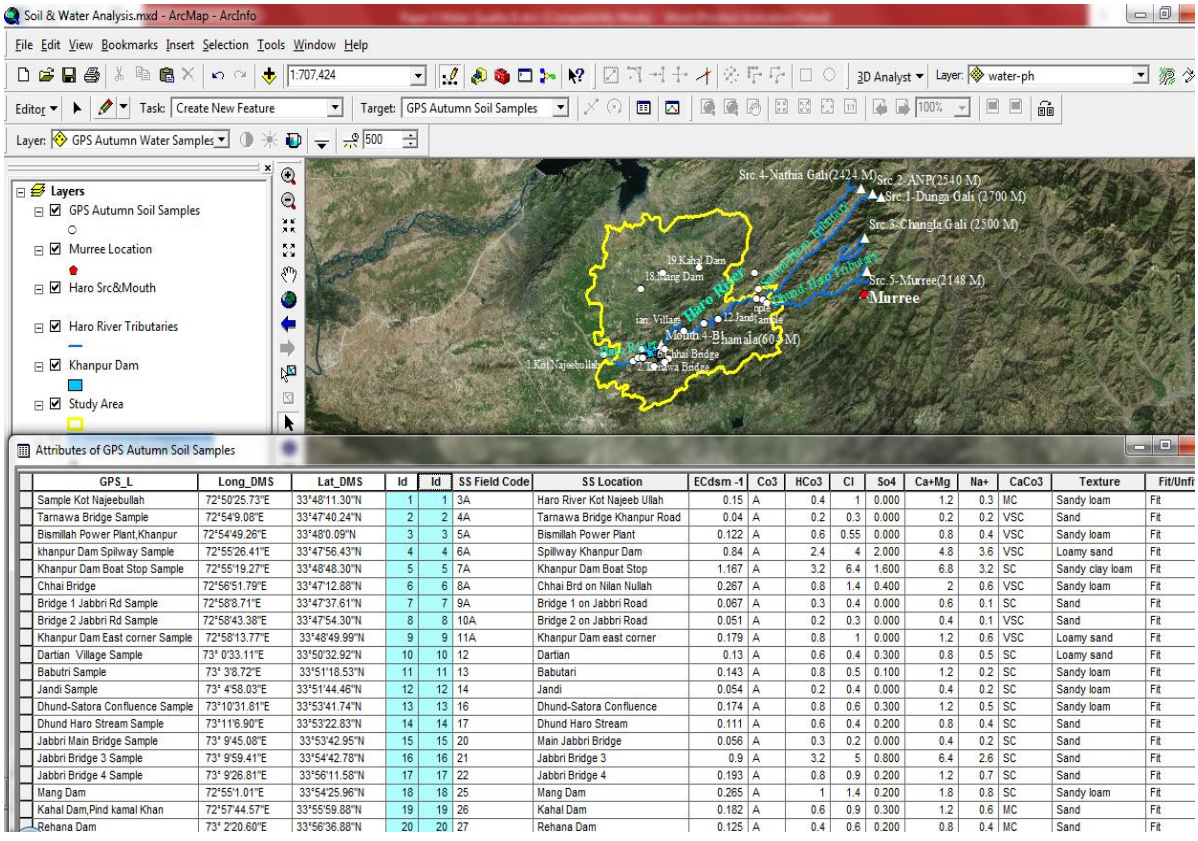
The parameters i.e. pH, EC, CO_2, HCO_3, Cl, SO_4, Ca+Mg, Na, $CaCO_3$ and texture of soil samples are assessed in the lab and an Excel sheet of all the parameters was prepared.

Assessed physico-chemical properties of soil and their spatial locations (spatial data) were integrated into Arc GIS by using the same integration technique of GIS (Fig. 4).



GPS_L	Long_DMS	Lat_DMS	Id	Id	WS Field Code	WS Location	PH	ECdsm -1	Turbidity	Co3	HCO3	Cl	So4	Ca+Mg	Na	K	RSC	F
Sample Kot Najeebullah	72°50'25.73"E	33°48'11.30"N	1	1	3A	Haro River Kot Najeeb Ullah	7.5	0.3	1.2	A	1.6	1.1	0.1	2.4	0.6	1	_Ve	Fit
Tarnawa Bridge Sample	72°54'9.08"E	33°47'40.24"N	2	2	4A	Tarnawa Bridge Khanpur Road	7.4	0.34	0.9	A	2	1.4	0.4	3.2	0.2	1.8	_Ve	Fit
Bismillah Power Plant,Khanpur	72°54'49.26"E	33°48'0.09"N	3	3	5A	Bismillah Power Plant	7.4	0.27	3.1	A	1.3	0.5	0.6	2.3	0.4	0.5	_Ve	Fit
khanpur Dam Spilway Sample	72°55'26.41"E	33°47'56.43"N	4	4	6A	Spillway Khanpur Dam	7.4	0.34	1.6	A	2.1	1.1	0.2	3	0.4	1	_Ve	Fit
Khanpur Dam Boat Stop Sample	72°55'19.27"E	33°48'48.30"N	5	5	7A	Khanpur Dam Boat Stop	7.4	0.31	0.7	A	1.7	0.6	0.4	2.8	0.3	0.2	_Ve	Fit
Chhai Bridge	72°56'51.79"E	33°47'12.88"N	6	6	8A	Chhai Brd on Nilan Nullah	7.2	0.36	1.8	A	2.4	1.1	0.5	3.4	0.2	0.6	_Ve	Fit
Bridge 1 Jabbri Rd Sample	72°58'8.71"E	33°47'37.61"N	7	7	9A	Bridge 1 on Jabbri Road	7.2	0.36	0.4	A	2.3	1.2	0.6	3.2	0.4	0.7	_Ve	Fit
Bridge 2 Jabbri Rd Sample	72°58'43.38"E	33°47'54.30"N	8	8	10A	Bridge 2 on Jabbri Road	7.3	0.35	0.4	A	2.1	1.4	0.1	3	0.5	0.15	_Ve	Fit
Khanpur Dam East corner Sample	72°58'13.77"E	33°48'49.99"N	9	9	11A	Khanpur Dam east corner	7.2	0.31	0.7	A	2	1	0.1	2.8	0.3	0.4	_Ve	Fit
Dartian Village Sample	73° 0'33.11"E	33°50'32.92"N	10	10	12	Dartian	7.3	0.33	0.3	A	2.2	1	0.1	2.7	0.5	0.3	_Ve	Fit
Babutri Sample	73° 3'8.72"E	33°51'18.53"N	11	11	13	Babutari	7.7	0.33	3.8	A	2.4	1.3	0.1	3.2	0.1	0.4	_Ve	Fit
Jandi Sample	73° 4'58.03"E	33°51'44.46"N	12	12	14	Jandi	8.1	0.29	7.5	A	2.7	0.2	0	2.4	0.4	0.2	_Ve	Fit
Dhund-Satora Confluence Sample	73°10'31.81"E	33°53'41.74"N	13	13	16	Dhund-Satora Confluence	7.6	0.38	0.2	A	3.2	0.4	0.2	3.6	0.2	0.4	_Ve	Fit
Dhund Haro Stream Sample	73°11'6.90"E	33°53'22.83"N	14	14	17	Dhund Haro Stream	7.1	0.34	1	A	2.8	0.4	0.4	3.2	0.3	0.5	_Ve	Fit
Jabbri Main Bridge Sample	73° 9'45.08"E	33°53'42.95"N	15	15	20	Main Jabbri Bridge	7.3	0.31	2.4	A	2	0.7	0.3	2.9	0.3	0.4	_Ve	Fit
Jabbri Bridge 3 Sample Landslided area	73° 9'59.41"E	33°54'42.78"N	16	16	21	Jabbri Bridge 3	7.0	0.41	0.2	A	2.8	1.4	0.9	3.8	0.2	0.6	_Ve	Fit
Jabbri Bridge 4 Sample	73° 9'26.81"E	33°56'11.58"N	17	17	22	Jabbri Bridge 4	7.2	0.35	0.5	A	2.6	1.2	0.2	2.8	0.7	0.8	_Ve	Fit
Khanpur Dam Center Sample	72°56'2.81"E	33°48'28.78"N	18	18	23	Khanpur Dam Centre	7.4	0.27	0.4	A	2.2	0.3	0.2	2.2	0.6	0.4	_Ve	Fit
khanpur Island Sample	72°55'48.87"E	33°48'53.14"N	19	19	24	Khanpor Dam Island	7.4	0.27	1	A	2.3	0.2	0.3	2.4	0.2	0.3	_Ve	Fit
Mang Dam,Pind Kamal Khan Sample	72°55'1.01"E	33°54'25.96"N	20	20	25	Mang Dam	7.2	0.19	1.5	A	1.2	0.7	0	2	0.1	0.2	_Ve	Fit
Kahal Dam,Pind kamal Khan Sample	72°57'44.57"E	33°55'59.88"N	21	21	26	Kahal Dam	6.9	0.31	1.2	A	2	0.6	0.5	2.8	0.3	0.1	_Ve	Fit
Rehana-Bhuttri Dam Sample	73° 2'20.60"E	33°56'36.88"N	22	22	27	Rehana Dam	6.9	0.23	0.8	A	1.4	0.6	0.3	2	0.3	0.2	_Ve	Fit

Fig. 3 Water samples' integration (spatial and non-spatial data in excel sheet) techniques.



GPS_L	Long_DMS	Lat_DMS	Id	Id	SS Field Code	SS Location	ECdsm -1	Co3	HCO3	Cl	So4	Ca+Mg	Na+	CaCo3	Texture	Fit/Unfi
Sample Kot Najeebullah	72°50'25.73"E	33°48'11.30"N	1	1	3A	Haro River Kot Najeeb Ullah	0.15	A	0.4	1	0.000	1.2	0.3	MC	Sandy loam	Fit
Tarnawa Bridge Sample	72°54'9.08"E	33°47'40.24"N	2	2	4A	Tarnawa Bridge Khanpur Road	0.04	A	0.2	0.3	0.000	0.2	0.2	VSC	Sand	Fit
Bismillah Power Plant,Khanpur	72°54'49.26"E	33°48'0.09"N	3	3	5A	Bismillah Power Plant	0.122	A	0.6	0.55	0.000	0.8	0.4	VSC	Sandy loam	Fit
khanpur Dam Spilway Sample	72°55'26.41"E	33°47'56.43"N	4	4	6A	Spillway Khanpur Dam	0.84	A	2.4	4	2.000	4.8	3.6	VSC	Loamy sand	Fit
Khanpur Dam Boat Stop Sample	72°55'19.27"E	33°48'48.30"N	5	5	7A	Khanpur Dam Boat Stop	1.167	A	3.2	6.4	1.600	6.8	3.2	SC	Sandy clay loam	Fit
Chhai Bridge	72°56'51.79"E	33°47'12.88"N	6	6	8A	Chhai Brd on Nilan Nullah	0.267	A	0.8	1.4	0.400	2	0.6	VSC	Sandy loam	Fit
Bridge 1 Jabbri Rd Sample	72°58'8.71"E	33°47'37.61"N	7	7	9A	Bridge 1 on Jabbri Road	0.067	A	0.3	0.4	0.000	0.6	0.1	SC	Sand	Fit
Bridge 2 Jabbri Rd Sample	72°58'43.38"E	33°47'54.30"N	8	8	10A	Bridge 2 on Jabbri Road	0.051	A	0.2	0.3	0.000	0.4	0.1	VSC	Sand	Fit
Khanpur Dam East corner Sample	72°58'13.77"E	33°48'49.99"N	9	9	11A	Khanpur Dam east corner	0.179	A	0.8	1	0.000	1.2	0.6	VSC	Loamy sand	Fit
Dartian Village Sample	73° 0'33.11"E	33°50'32.92"N	10	10	12	Dartian	0.13	A	0.6	0.4	0.300	0.8	0.5	SC	Loamy sand	Fit
Babutri Sample	73° 3'8.72"E	33°51'18.53"N	11	11	13	Babutari	0.143	A	0.8	0.5	0.100	1.2	0.2	SC	Sandy loam	Fit
Jandi Sample	73° 4'58.03"E	33°51'44.46"N	12	12	14	Jandi	0.054	A	0.2	0.4	0.000	0.4	0.2	SC	Sandy loam	Fit
Dhund-Satora Confluence Sample	73°10'31.81"E	33°53'41.74"N	13	13	16	Dhund-Satora Confluence	0.174	A	0.8	0.6	0.300	1.2	0.5	SC	Sandy loam	Fit
Dhund Haro Stream Sample	73°11'6.90"E	33°53'22.83"N	14	14	17	Dhund Haro Stream	0.111	A	0.6	0.4	0.200	0.8	0.4	SC	Sand	Fit
Jabbri Main Bridge Sample	73° 9'45.08"E	33°53'42.95"N	15	15	20	Main Jabbri Bridge	0.056	A	0.3	0.2	0.000	0.4	0.2	SC	Sand	Fit
Jabbri Bridge 3 Sample	73° 9'59.41"E	33°54'42.78"N	16	16	21	Jabbri Bridge 3	0.9	A	3.2	5	0.800	6.4	2.6	SC	Sand	Fit
Jabbri Bridge 4 Sample	73° 9'26.81"E	33°56'11.58"N	17	17	22	Jabbri Bridge 4	0.193	A	0.8	0.9	0.200	1.2	0.7	SC	Sand	Fit
Mang Dam	72°55'1.01"E	33°54'25.96"N	18	18	25	Mang Dam	0.265	A	1	1.4	0.200	1.8	0.8	SC	Sandy loam	Fit
Kahal Dam,Pind kamal Khan	72°57'44.57"E	33°55'59.88"N	19	19	26	Kahal Dam	0.182	A	0.6	0.9	0.300	1.2	0.6	MC	Sand	Fit
Rehana Dam	73° 2'20.60"E	33°56'36.88"N	20	20	27	Rehana Dam	0.125	A	0.4	0.6	0.200	0.8	0.4	MC	Sand	Fit

Fig. 4 Soil samples Integration (Spatial and non-spatial data in excel sheet) techniques.

Table 1 The GPS locations of soil samples.

Id	Field Code	GPS Locations of Soil samples	Latitude	Longitude
1	3A	KotNajeebullah	33°48'11.30"N	72°50'25.73"E
2	4A	Tarnawa Bridge	33°47'40.24"N	72°54'9.08"E
3	5A	Bismillah Power Plant,Khanpur	33°48'0.09"N	72°54'49.26"E
4	6A	Khanpur Dam Spillway	33°47'56.43"N	72°55'26.41"E
5	7A	Khanpur Dam Boat Stop	33°48'48.30"N	72°55'19.27"E
6	8A	Chhai Bridge	33°47'12.88"N	72°56'51.79"E
7	9A	Bridge 1 on Jabbri Road	33°47'37.61"N	72°58'8.71"E
8	10A	Bridge 2 on Jabbri Road	33°47'54.30"N	72°58'43.38"E
9	11A	Khanpur Dam east corner	33°48'49.99"N	72°58'13.77"E
10	12	Dartian village	33°50'32.92"N	73° 0'33.11"E
11	13	Babutari village	33°51'18.53"N	73° 3'8.72"E
12	14	Jandi village	33°51'44.46"N	73° 4'58.03"E
13	16	Dhund-Satora Confluence	33°53'41.74"N	73°10'31.81"E
14	17	DhundHaro Stream	33°53'22.83"N	73°11'6.90"E
15	20	Main Jabbri Bridge	33°53'42.95"N	73° 9'45.08"E
16	21	Jabbri Bridge 3	33°54'42.78"N	73° 9'59.41"E
17	22	Jabbri Bridge 4	33°56'11.58"N	73° 9'26.81"E
18	25	Mang Dam	33°54'25.96"N	72°55'1.01"E
19	26	Kahal Dam	33°55'59.88"N	72°57'44.57"E
20	27	Rehana Dam	33°56'36.88"N	73° 2'20.60"E

Table 2 The parameters of soil samples in southern Haripur Tehsil.

Id	SS F-Code	SS Location	PH	ECdsm^{-1}	CO_3	HCO_3	Cl	SO_4	Ca+Mg	Na+	$CaCO_3$	Texture	Fit/Unfit
1	3A	Haro R KotNajeebUllah	8.2	0.15	A	0.4	1	A+	1.2	0.3	MC	Sandy loam	Fit
2	4A	TarnawaBrdKhanpur	8.35	0.04	A	0.2	0.3	A	0.2	0.2	VSC	Sand	Fit
3	5A	Bismillah Power Plant	7.7	0.122	A	0.6	0.55	A	0.8	0.4	VSC	Sandy loam	Fit
4	6A	Spillway Khanpur Dam	7.4	0.84	A	2.4	4	2	4.8	3.6	VSC	Loamy sand	Fit
5	7A	Khanpur Dam Boat Stop	7.66	1.167	A	3.2	6.4	1.6	6.8	3.2	SC	Sandy clay loam	Fit
6	8A	ChhaiBrd on NilanNullah	7.5	0.267	A	0.8	1.4	0.4	2	0.6	VSC	Sandy loam	Fit
7	9A	Brd 1 on Jabbri Rd	7.91	0.067	A	0.3	0.4	A	0.6	0.1	SC	Sand	Fit
8	10A	Brd 2 on Jabbri Rd	7.9	0.051	A	0.2	0.3	A	0.4	0.1	VSC	Sand	Fit
9	11A	Khanpur Dam east corner	7.2	0.179	A	0.8	1	A	1.2	0.6	VSC	Loamy sand	Fit
10	12	Dartian	8.1	0.13	A	0.6	0.4	0.3	0.8	0.5	SC	Loamy sand	Fit
11	13	Babutari	7.83	0.143	A	0.8	0.5	0.1	1.2	0.2	SC	Sandy loam	Fit
12	14	Jandi	7.9	0.054	A	0.2	0.4	A	0.4	0.2	SC	Sandy loam	Fit
13	16	Dhund-Satora Confluence	8.04	0.174	A	0.8	0.6	0.3	1.2	0.5	SC	Sandy loam	Fit
14	17	DhundHaro Stream	8.32	0.111	A	0.6	0.4	0.2	0.8	0.4	SC	Sand	Fit
15	20	Main JabbriBrd	7.8	0.056	A	0.3	0.2	A	0.4	0.2	SC	Sand	Fit
16	21	JabbriBrd 2	7.7	0.9	A	3.2	5	0.8	6.4	2.6	SC	Sand	Fit
17	22	JabbriBrd 3	7.51	0.193	A	0.8	0.9	0.2	1.2	0.7	SC	Sand	Fit
18	25	Mang Dam	7.43	0.265	A	1	1.4	0.2	1.8	0.8	SC	Sandy loam	Fit
19	26	Kahal Dam	8.1	0.182	A	0.6	0.9	0.3	1.2	0.6	MC	Sand	Fit
20	27	Rehana Dam	7.85	0.125	A	0.4	0.6	0.2	0.8	0.4	MC	Sand	Fit

Results and Discussion

Following parameters of soil samples were interpolated in the Arc GIS software 9.3 using GIS technique of interpolation named IDW (Inverse Distance weighted).Trends of following parameters of soil was identified as given below:

After using IDW technique of interpolation the minimum value (7.2 to 7.32) of soil pH was found 9.The maximum value (8.22 to 8.35) of pH soil was determined in soil sample 2 beyond the spillway of Khanpur dam (Fig. 5).

The minimum range of Electrical Conductivity (ECdsm-1) of soil in the area was found from 0.0405 to 0.1656 dsm^{-1} along the samples 2, 7, 8, 10,11,12,13, 14and 15.The maximum range of EC from 1.04 to 1.16 dsm-1 was found near the sample 5 and CO_3 was analyzed and found nil in all soil samples**.** Soil parameter of HCO_3 was found in the range of 0.2 to 0.53 in samples2, 7, 8, 12, 15and 20 (Table 2).

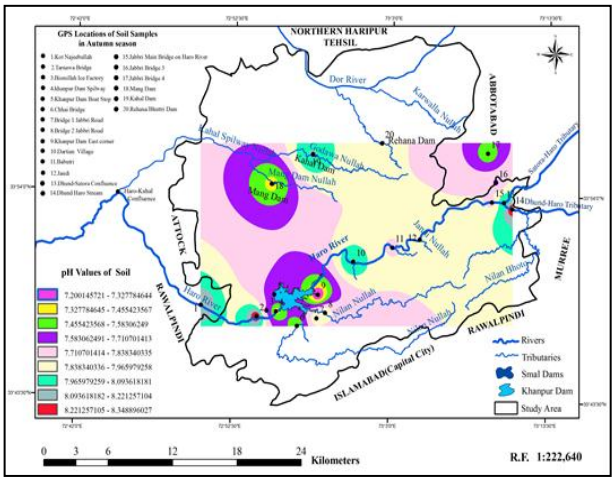


Fig. 5. The pH trends of soil in the study area.

Chloride in soil was found in minimum range from 0.2 to 0.88 in samples 2,7,8,10,11,12, 13,14,15 and maximum value of chlorine was found near sample 5. Minimum value from 0.00 to 0.22 of SO_4 was found in the soil samples (2, 7, 8, 9, 11, 12, 14, 15, 18 and 20). The maximum content of SO_4 (1.77 to 1.99) was obtained in sample 4. The (Ca+Mg) content of soil samples was minimum (0.2 to 0.93) in samples 2, 7, 8, 9, 10, 12, 14, 15 and 20 and its maximum value (6.06 to 6.79) was found in 5 and 16.

Value of Na in study area was found minimum (0.1 to 0.488) in samples 2,7,8,10,12,14,15. Maximum range (3.21-3.59) was found in samples 4, 5 and 16 (Sureshi et al., 2010). $CaCO_3$ content was categorized as moderately calcareous in samples 1, 19 and 20; strongly calcareous in samples 5,7,10,11,12,13,1 4,15,16,17,18 and very strongly calcareous in samples 2, 3, 4, 6, 8, and 9 (Fig. 6).

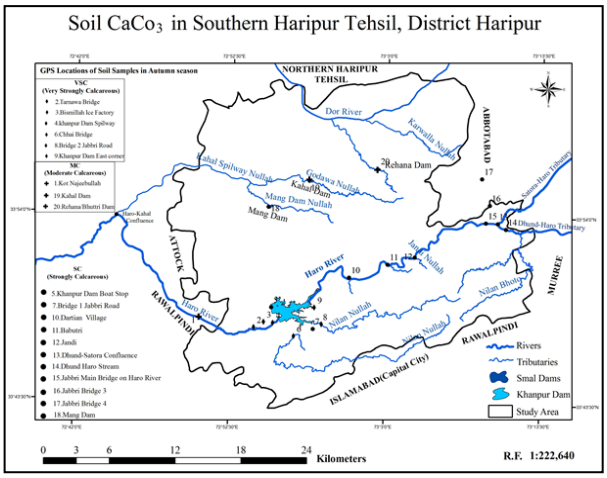


Fig. 6 Classes of $CaCO_3$ in study area.

Soil textural classification was determined by the percentage of sand, silt and clay tested in collected samples from the study area. From these percentages, four soil textures are then classified according to the soil textural triangle.

It was found that the sandy clay loam textural class was shown in soil sample 5. While, sandy loam type soil was at 1, 3, 6, 11, 12, 13, 18 locations, Loamy sand texture was determined in samples 4, 9, 10. Further, sand type was found in soil samples 2, 7, 8, 14, 15, 16, 17, 19 and 20 (Fig. 7).

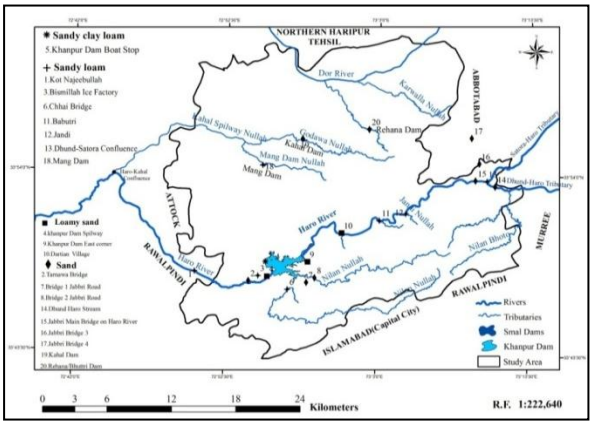


Fig. 7 Textural classes of soil in the study area.

The soil of the study area was suitable for agricultural purpose especially for maize and wheat, peanut and citrus orchards cultivation in southern Haripur Tehsil. It was found that sandy soil was moderately suitable. While, loamy sand, sandy loam and sandy clay loam were most suitable for agricultural purpose (Fig. 7). Tests of water samples indicated that water was highly suitable for the maize, wheat, peanuts and citrus orchids which are also the main crops, grown in study area.

In Figure 8 the higher value of soil pH was found in soil sample 14. Values of Ca+Mg were higher in sample 5. Electrical conductivity of soil was higher in location 5 and lower in sample 2. Linear trend indicated the higher contents of HCO_3 in sample 5 and 16 and lower values were found in samples 2, 8 and 12 (Table 2).

In Figure 9 the bar graph showed higher content of sodium (Na) was in sample 4 and lower concentrations were obtained in samples 7 and 8. The Cl content was found higher in sample 5 and lower in sample 15.The bar graph was found very low for all soil parameters except pH.

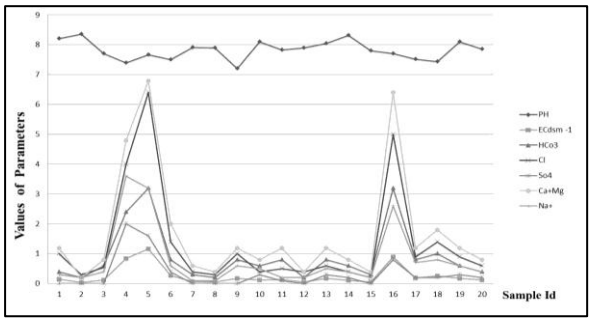


Fig. 8 Showing the linear trend in different soil parameters.

Table 3 Shows the parameters of water samples in southern Haripur Tehsil.

Id	WS F-Code	WS Location	PH	ECdsm^{-1}	Turbidity	CO_3	HCO_3	Cl	SO_4	Ca+ Mg	Na	K	RSC	Fit/ Unfit
1	3A	Haro R KotNajeebUllah	7.5	0.3	1.2	A	1.6	1.1	0.1	2.4	0.6	1	_Ve	Fit
2	4A	TarnawaBrdKhanpur Rd	7.43	0.34	0.9	A	2	1.4	0.4	3.2	0.2	1.8	_Ve	Fit
3	5A	Bismillah Power Plant	7.48	0.27	3.1	A	1.3	0.5	0.6	2.3	0.4	0.5	_Ve	Fit
4	6A	Spillway Khanpur Dam	7.4	0.34	1.6	A	2.1	1.1	0.2	3	0.4	1	_Ve	Fit
5	7A	Khanpur Dam Boat Stop	7.4	0.31	0.7	A	1.7	0.6	0.4	2.8	0.3	0.2	_Ve	Fit
6	8A	ChhaiBrd on NilanNullah	7.2	0.36	1.8	A	2.4	1.1	0.5	3.4	0.25	0.6	_Ve	Fit
7	9A	Brd 1 on Jabbri Rd	7.26	0.36	0.4	A	2.3	1.2	0.6	3.2	0.41	0.7	_Ve	Fit
8	10A	Brd 2 on Jabbri Rd	7.3	0.35	0.4	A	2.1	1.4	0.1	3	0.5	0.15	_Ve	Fit
9	11A	Khanpur Dam east corner	7.29	0.31	0.7	A	2	1	0.1	2.8	0.3	0.4	_Ve	Fit
10	12	Dartian	7.33	0.33	0.3	A	2.2	1	0.1	2.7	0.5	0.3	_Ve	Fit
11	13	Babutari	7.75	0.33	3.8	A	2.4	1.3	0.1	3.2	0.1	0.4	_Ve	Fit
12	14	Jandi	8.11	0.29	7.5	A	2.7	0.2	A	2.4	0.4	0.2	_Ve	Fit
13	16	Dhund-Satora Confluence	7.64	0.38	0.2	A	3.2	0.4	0.2	3.6	0.2	0.4	_Ve	Fit
14	17	DhundHaro Stream	7.19	0.34	1	A	2.8	0.4	0.4	3.2	0.3	0.5	_Ve	Fit
15	20	Main JabbriBrd	7.33	0.31	2.4	A	2	0.7	0.3	2.9	0.3	0.4	_Ve	Fit
16	21	JabbriBrd 2	7.05	0.41	0.2	A	2.8	1.4	0.9	3.8	0.2	0.6	_Ve	Fit
17	22	JabbriBrd 3	7.25	0.35	0.5	A	2.6	1.2	0.2	2.8	0.7	0.8	_Ve	Fit
18	23	Khanpur Dam Centre	7.45	0.27	0.4	A	2.2	0.3	0.2	2.2	0.6	0.4	_Ve	Fit
19	24	Khanpor Dam Island	7.47	0.27	1	A	2.3	0.2	0.3	2.4	0.2	0.3	_Ve	Fit
20	25	Mang Dam	7.26	0.19	1.5	A	1.2	0.7	A	2	0.1	0.2	_Ve	Fit
21	26	Kahal Dam	6.94	0.31	1.2	A	2	0.6	0.5	2.8	0.3	0.1	_Ve	Fit
22	27	Rehana Dam	6.99	0.23	0.8	A	1.4	0.6	0.3	2	0.3	0.2	_Ve	Fit

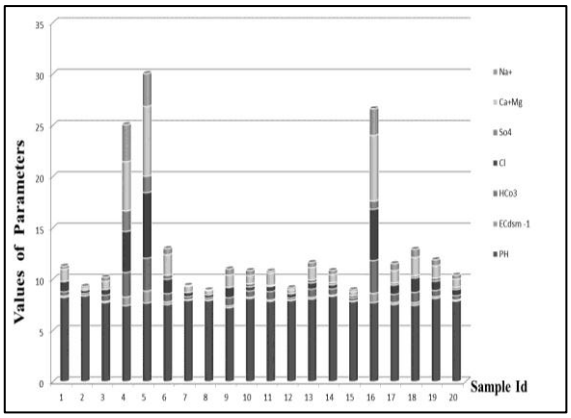


Fig. 9Showing variation in soil parameters.

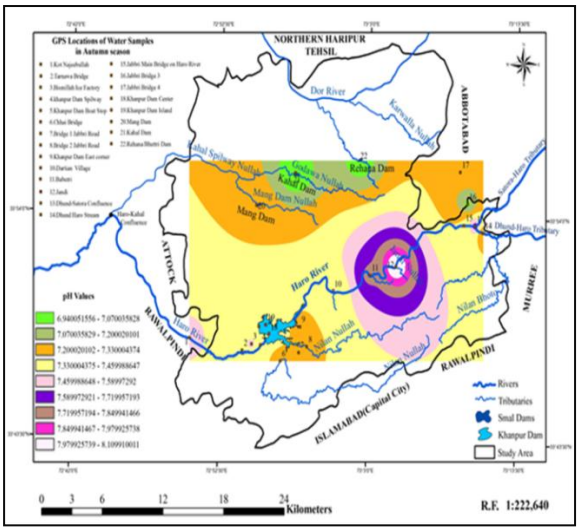


Fig. 10 Trend of water pH in the study area.

Physicochemical properties of water

The physico-chemical properties of water were determined in the lab and the parameters of water i.e. pH, EC, turbidity, CO_3, HCO_3, Cl, SO_4, Ca+Mg, Na and K were interpolated using GIS technique of IDW.

The pH of water was found in minimum range of 6.94 to 7.07 in samples 16, 21and22 and maximum from 7.97 to 8.11 in sample 12(Fig.10).

Electrical conductivity **(**EC dsm^{-1}EC) of water was found in minimum range (0.19 to 0.2)1 in sample 20 and maximum (0.28 to 0.41) in water sample 16. In Figure 11 the graph showed the linear trend of higher values of pH and turbidity of water in sample 12, while lower content of potassium (K) was obtained in sample21.

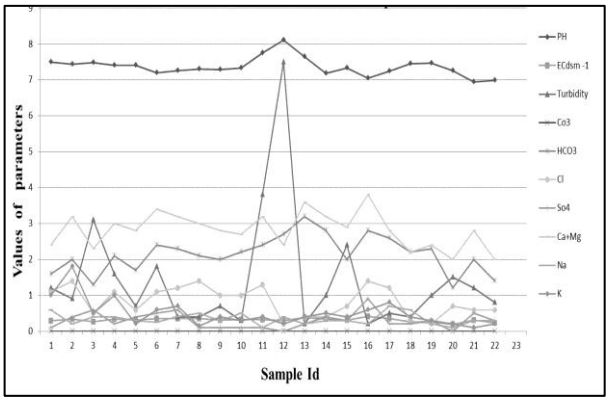


Fig. 1 Linear trend in different water parameters.

The Figure 12 showed clearly higher values of water pH and turbidity and lower concentrations of K in sample 21.The minimum range of water turbidity was found from 0.2 to 1.01 in samples 2, 5, 6, 7, 8, 9, 10, 13, 14, 16, 18, 19 and 22 and maximum turbidity range was obtained from 6.68 to 7.49 in sample 12.

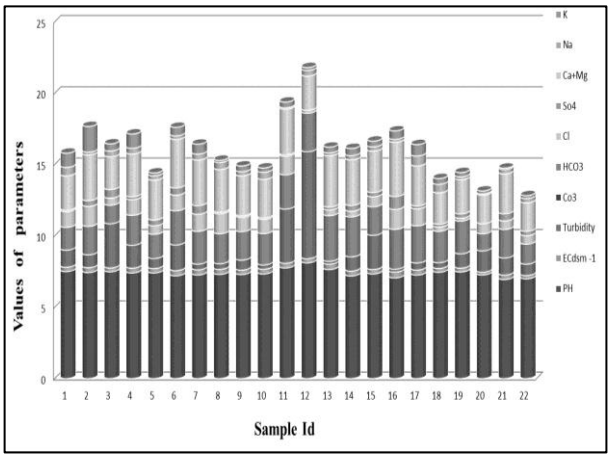


Fig. 12 Show variation in water parameters.

CO_3 was found nil in all the water samples. Minimum value of HCO_3 of water ranged from 1.2 to 1.42 in samples 20 and 22 and maximum (2.97 to 3.19) was determined in sample 13. Minimum chloride (Cl) ranged from 0.2 to 0.33 in sample 12 and its maximum concentration was found (1.26 to 1.39) in samples 2,7,11 and 16.

Minimum range of SO_4 in water was found from 0.00 to 0.09 in samples 12 and 20. While maximum value was obtained from 0.79 to 0.89 in sample 16. Minimum (Ca+Mg) content was found from 2.00 to 2.2 in samples 20 and 22 and maximum content was found from 3.59 to 3.79 in sample 16. Minimum contents of Na (0.1 to 0.16) in sample 11 and 20 and maximum range (0.43 to 0.49) concentration were found in samples 8 and 10 (Jalil and Khan. 2012).

The minimum range (0.1 to 0.28) of potassium (K) was obtained from samples 8, 12, 20, 21and 22 and maximum; value was in range of 1.61 to 1.79 in sample 2.

RSC (Residual Sodium Carbonate) of 22 water samples was also analyzed and found negative which means it was not fit for irrigation. Calculated Sodium Adsorption Ratio (RSC) was interpolated using GIS interpolation technique of IDW available in 3D analyst extension tool of Arc GIS 9.3 software. It was found in minimum range (0.08-0.13) in sample 11 and 20. Maximum value of RSC ranged from 0.53-0.58 in water sample 18 taken from the Khanpur dam centre.

Conclusion

This study was conducted to evaluate the physio-chemical properties of soil and water for agricultural purpose. Forty two samples (20 of soil and 22 of water) were collected from the area. It was found that water pH was in the range of 6.94 to 8.11 while EC dsm-1 ranged from 0.19 to 0.41 which was within the normal range with no salinity and sodicity hazard. Water is fit for irrigation. Soil data showed that pH was in the range of 7.2 to 8.32 and EC dsm-1 ranged 0.04 to 1.16. It was concluded that sandy soil was moderately suitable and loamy sand, sandy loam and sandy clay loam soils were most suitable for agricultural purpose especially for maize, wheat, peanuts and citrus orchids.

The water sample analysis indicated that water is highly suitable for maize and wheat, which are main crops of the area. It was also concluded by the analysis of soil and water in Arc GIS software that GIS techniques were very useful to identify the trends of soil and water parameters in the study area. GIS tools provided best fit results for further analysis for different applications. Further, remote sensing and GPS survey techniques were also useful for finding the location of all samples on the satellite image and in the ground respectively.

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