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Surface and Ground Water Quality Risk Assessment in District Attock Pakistan

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Abstract: The present study is aimed at assessing the water quality index (WQI) for the surface and ground water in the study area of Attock City, Punjab, Pakistan. This has been determined by collecting 30 water samples each from boreholes, municipal water supply and Kabul River. For calculating the WQI, the following parameters have been considered: temperature, pH, conductivity, TDS, DO, nitrate and sulphate. The high value of WQI has been found to be mainly from the higher values of nitrates, while other parameters in all samples were in safe limits. The analysis reveals that the surface and ground water of the area needs some degree of treatment before consumption.

Key words: Water chemistry · Environmental chemistry · Water quality index · Risk assessment

INTRODUCTION

Industry, agriculture and sewage are among major polluter of water [1,2,3]. According to WHO survey, 60% diseases in the Asian countries are water borne [4,5]. WHO recorded 315 cases of water borne diseases out of 100,000 in the world [6]. It has been reported in a “Community Health Study” that 30% of all reported cases of illness and 40% of deaths in Pakistan, one way or another are related to water borne diseases [7]. The anions of nitrates and sulphates are very important both from environmental as well as industrial point of view [8,9]. Temperature, pH, alkalinity, TDS, DO nitrate and sulphate etc. are basically important in determining the water quality [10]. Temperature and pH effects on chemical toxicity need to be considered in chemical hazard assessment to ensure adequate protection of aquatic organisms [11]. The use of nitrate as fertilizer is the major source of aquatic nitrate pollution. Excessive amount of nitrate in water causes eutrophication. Eutrophication acidification and water contamination by heavy metals and other pollutants are problems that need to be tackled in a sustainable manner. This process lowers DO, leads to killing fish and causes retardation in the plant growth [12,13]. Ground and surface water which is contaminated especially with nitrates & phosphorus pollutants from fertilizers by leaching of fertilizer [14,15]. Sulphates are discharged into water from mines, smelters, kraft pulp, paper mills, textile mills and tanneries. Sulphur trioxide produced by the photolytic oxidation of sulphur dioxide combines with water vapors to form dilute sulphuric acid which fall as ‘acid rain’ [16]. Sulphate may also contribute to the corrosion of the distribution system. However high level of sulphates in water is undesirable because it causes non carbonate hardness responsible for scale formation in the boiler at high temperature [17]. Water Quality Index (WQI) is one of the most effective ways to communicate information on the water quality to the concerned citizens and the policy makers [18,19]. Pollution and waste due to industrial exploitation and overpopulation are a serious threat to our freshwater resources [20]. In this paper, the quality of ground and surface water of people colony, Attock City, Punjab, Pakistan has been investigated by calculating the water quality indices.

MATERIALS AND METHODS

Ninety samples were collected, thirty each from borehole, municipal water supply and Kabul River. The samples (1.5 liters) were collected directly from the source at the discharge point in new plastic containers cleaned with the same water several times. The samples were labeled and transported to the laboratory, stored in the refrigerator at about 4°C prior to analysis. The taste and color was checked at the spot. The temperature was measured with ordinary centigrade thermometer while pH, electrical conductivity, DO (dissolved oxygen), nitrates

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and sulphates were measured in laboratory. pH was determined by calibrated pH meter of model Orion 410 Plus, Germany. The pH meter was calibrated using HACH (1997) buffers of pH 4, 7 and 10 DO (dissolved oxygen) was determined by Inolab Oxi Level 2P, Germany. Dissolved oxygen (DO) meter was calibrated prior to measurement with the appropriate calibration solution (5%HCl) in accordance with the manufacturer's instruction. The dissolved oxygen content was determined before and after incubation. Sample incubation was for 5 days at 20°C. Conductivity of the samples was measured using pre-calibrated conductivity meter of model Con 510, Germany. The power key and the conductivity key of the conductivity meter were switched on and the meter was also temperature adjusted; the instrument was calibrated with 0.001M KCl to give a value of 14.7µS/m at 25°C. The probe was dipped below the surface of the water. Time was allowed for the reading to be stabilized and reading was recorded. The probe was thoroughly rinsed with distilled water after each measurement. All field meters and equipment were checked and calibrated according to the manufacturer's specifications. A glass thermometer was used to measure temperature of water samples collected from different sampling points. Standard methods were followed in determining the above variables [21].

Determination of Nitrate: The concentration of nitrate was determined using by UV-visible spectrophotometer of model UV-1601, Schimadzu, Japan. The spectrophotometers were checked for malfunctioning by passing standard solutions of all the parameters to be measured; blank samples (deionized water) were passed between every three measurements of water samples to check for any eventual contamination or abnormal response of equipment [22].

Determination of Sulphate: For sulphate determination, 5ml of magnesium nitrate solutions were added to each of the ground and sieved samples in the crucibles. These were then heated to 180°C on a hot plate. The heating process was allowed to continue until the colour of the samples changed from brown to yellow. The samples were then transferred to the furnace at a temperature of 500°C for four hours. Magnesium nitrate was added to prevent loss of sulphur. The contents of each crucible were carefully transferred to different evaporating basins. 10ml of concentrated HCl were added to each of them and covered with watch glasses. They were boiled on a steam bath for 3 minutes. On cooling, 10ml of distilled water were added to each of the basins and the contents of each were filtered into 50ml volumetric flasks and the volumes made up to the marks with distilled water [23].

RESULTS AND DISCUSSION

The water temperature changes appreciably as a function weather condition prevailing in a given area below. The temperature of boreholes samples varied between 33-37°C. In the municipal water supply samples the temperature was ranging in between 31-34°C. Kabul River was ranging in between 30-35°C. The limiting temperature value as recommended by NEQS is 40°C [24]. The rise in the temperature increases the metabolic rate of the organisms present, exerts great demands on the oxygen resources of the stream thus amplifying the problem [25]. The levels of the physicochemical parameters are presented in Table 1A, Table 1B and Table 1C. Total ninety samples were collected: thirty samples each were from boreholes, municipal water supply and Kabul River of people colony, Attock City, Punjab, Pakistan. All the results are presented as average values of studied parameters. pH of samples were in the permissible limits of WHO standards. According to IUPAC standards pH should lied between 7.5-8 [26]. In thirty samples of the bore water the minimum value was 7.14, the maximum value 7.99 and average value lied round about 7.61. In case of municipal water supply the maximum pH was 8.01 and the minimum was 7.21. The average value is seen to be 7.74, so the values are in the permissible limits [27].

The electric conductivity values were recorded; in the entire bore water samples it was found that the minimum value was of sample 3B i.e. 368µS/cm while sample 29B has highest value 825µS/cm and average value of all samples was 540.26µS/cm. In municipal water the lowest value was 512µs/cm and the highest was µs/cm. In river water the highest EC value is 613µs/cm and lowest value is 431µs/cm, average value is 467.52µS/cm This variability in electrical conductivity is due to the presence of different salts or solids [28].

In bore water samples the results show that 3.1mg/L is lowest nitrates while in sample 23B was having 26.8 mg/L nitrates. Average value of nitrates was 10.35 mg/L. It is slightly higher than permissible limits. In municipal water supply the highest value of nitrate is 15.6mg/L, lowest is 8.6mg/L and the average value of nitrate concentration for all samples are 11.68mg/L. Almost 90% samples were having nitrates concentration above the permissible level of WHO standards. n river water samples

Table 1A: Physicochemical analysis of bore water, people colony Attock city Pakistan

Sample Codes	pH	Conductivity µS/cm	Nitrate mg/L	Sulphate mg/L	TDS mg/L	DO mg/L
1B	7.40	497.00	8.90	29.20	372.75	3.96
2B	7.68	536.00	8.20	37.60	402.00	3.94
3B	7.33	368.00	3.70	24.80	276.00	3.78
4B	7.90	571.00	5.10	40.80	428.25	3.85
5B	7.72	439.00	3.80	32.80	329.25	3.78
6B	7.74	424.00	3.70	32.00	318.00	3.95
7B	7.96	556.00	8.50	36.40	417.00	3.98
8B	7.86	578.00	8.40	41.60	433.50	3.50
9B	7.77	414.00	3.10	28.00	310.50	3.89
10B	7.65	530.00	5.30	35.60	397.50	3.81
11B	7.70	526.00	10.20	43.20	394.50	4.07
12B	7.32	785.00	19.20	80.80	588.75	3.66
13B	7.52	459.00	11.80	34.80	344.25	4.06
14B	7.80	562.00	11.20	44.80	421.50	4.03
15B	7.61	539.00	14.60	48.40	404.25	4.02
16B	7.14	730.00	23.70	50.80	547.50	4.03
17B	7.71	553.00	8.60	25.60	414.75	4.12
18B	7.75	453.00	10.20	15.60	339.75	4.13
19B	7.63	423.00	6.70	15.20	317.25	4.05
20B	7.80	793.00	19.80	66.00	594.75	4.14
21B	7.28	544.00	10.80	29.60	408.00	3.90
22B	7.26	468.00	6.80	29.20	351.00	3.98
23B	7.33	785.00	26.80	54.40	588.75	3.93
24B	7.98	449.00	7.60	20.80	336.75	4.04
25B	7.98	464.00	7.70	23.60	348.00	4.14
26B	7.97	479.00	8.20	25.20	359.25	4.11
27B	7.79	493.00	7.80	31.20	369.75	4.14
28B	7.99	425.00	5.90	24.00	318.75	4.02
29B	7.93	825.00	22.70	17.20	618.75	4.15
30B	7.63	540.00	11.60	44.00	405.00	4.14
Minimum	7.14	368.00	3.10	15.20	276.00	3.50
Maximum	7.99	825.00	26.80	80.80	618.75	4.15
Average	7.671	540.26	10.35	35.40	405.20	3.976
St. deviation	0.246	123.48	6.20	14.60	92.61	0.1553

Table 1B: Physicochemical analysis of municipal water, people colony Attock city Pakistan

Sample Code	pH	Conductivity µS/cm	Nitrate mg/liter	Sulphate mg/liter	TDS mg/liter	DO mg/liter
1M	8.01	579.00	11.90	37.60	434.25	4.09
2M	7.91	566.00	12.60	38.00	424.50	4.09
3M	7.90	546.00	11.60	42.40	409.50	4.10
4M	7.98	566.00	11.90	40.80	424.50	4.18
5M	7.91	566.00	11.80	41.20	424.50	4.18
6M	7.80	542.00	8.60	28.40	406.50	4.14
7M	7.86	536.00	11.20	29.60	402.00	4.14
8M	7.67	553.00	11.80	42.40	414.75	4.04
9M	7.67	573.00	11.90	40.80	429.75	4.13
10M	7.68	655.00	15.60	48.80	491.2525	4.12
11M	8.00	563.00	11.80	43.20	422.25	4.15
12M	7.94	575.00	12.30	49.20	431.25	4.09
13M	7.86	546.00	13.90	36.20	409.50	3.92
14M	7.83	567.00	12.90	48.00	425.30	4.11

Table 1B: Continued

15M	7.75	565.00	11.50	39.20	423.75	4.09
16M	7.83	573.00	11.20	34.00	429.75	4.14
17M	7.58	560.00	10.60	37.60	426.75	4.12
18M	7.31	667.00	14.30	20.00	500.75	4.13
19M	7.73	557.00	10.50	40.40	417.25	4.09
20M	7.78	527.00	10.90	33.60	395.25	4.12
21M	7.76	566.00	11.20	44.80	417.00	4.14
22M	796.00	512.00	11.10	36.80	384.00	4.02
23M	7.85	574.00	9.90	44.20	430.25	4.12
24M	7.69	667.00	10.80	41.20	425.25	3.58
25M	7.21	543.00	13.70	49.20	411.75	3.13
26M	7.52	546.00	10.00	37.20	409.50	3.89
27M	7.88	519.00	10.00	46.00	389.25	4.11
28M	7.25	518.00	9.80	42.00	388.50	4.04
29M	7.44	635.00	12.5s	16.00	476.25	3.70
30M	7.39	679.00	12.80	85.20	509.25	3.40
Minimum	7.21	512.00	8.60	16.00	384.00	3.13
Maximum	8.01	679.00	15.60	85.20	509.25	4.18
Average	7.74	568.23	11.68	40.50	426.14	4.013
St. deviation	0.20	40.73	1.47	11.45	30.623	0.243

Table 1C: Physicochemical analysis of Kabul river Attock city Pakistan

Sample Code	PH	Conductivity µS/cm	Nitrate mg/L	Sulphate mg/L	TDS mg/L	DO mg/L
1R	7.10	478.00	2.80	65.20	358.50	6.43
2R	7.34	479.00	2.90	53.20	359.25	6.10
3R	7.17	488.00	2.60	48.40	366.00	6.22
4R	7.59	456.00	5.50	56.80	348.75	5.92
5R	7.56	459.00	2.20	53.60	344.25	6.01
6R	7.63	440.00	2.50	51.60	330.00	4.95
7R	7.49	473.00	7.50	50.00	354.75	6.15
8R	7.67	467.00	3.90	61.20	348.00	6.43
9R	7.67	445.00	3.20	73.20	333.50	6.20
10R	7.66	453.00	3.90	72.80	340.25	5.93
11R	7.68	436.00	3.20	72.90	327.00	4.83
12R	7.67	469.00	2.80	52.80	348.75	6.39
13R	7.70	440.00	2.30	49.20	330.00	6.05
14R	7.66	434.00	2.10	48.40	325.75	6.35
15R	7.64	453.00	4.80	48.50	339.75	4.61
16R	7.53	413.00	2.60	50.00	459.75	6.38
17R	7.46	442.00	2.60	48.00	331.50	6.41
18R	7.88	439.00	2.70	46.00	325.25	5.88
19R	7.72	464.00	3.10	68.00	348.00	6.48
20R	7.67	482.00	4.10	95.20	361.50	6.40
21R	7.81	445.00	2.90	103.20	333.25	6.34
22R	7.78	576.00	2.30	94.40	432.00	6.43
23R	7.75	481.00	2.20	85.20	360.75	6.40
24R	7.69	496.00	2.30	62.00	372.00	6.29
25R	7.35	491.00	2.60	84.40	368.75	6.33
26R	7.73	478.00	2.40	86.40	358.50	6.57
27R	7.77	473.00	2.90	97.60	327.75	6.45
28R	7.33	431.00	3.30	69.60	323.75	6.22
29R	7.78	439.00	3.20	68.00	329.25	6.22
30R	7.75	432.00	3.20	69.60	324.00	6.27
Minimum	7.10	431.00	2.10	46.00	323.75	4.61
Maximum	7.88	613.00	7.50	103.20	459.75	6.57
Average	7.60	467.56	3.20	66.06	50.75	6.121
St.deviation	0.18	39.80	1.123	17.52	30.20	0.484

all were having nitrates in the limits not a single sample was exceeding the level. The highest value of nitrates in river was 7.5mg/L and the lowest was 2.1mg/L. Average values are 3.2mg/L. According to Cutcheon and co-workers, ground water contaminated with pesticide has higher concentration of nitrate [29]. Santamaria and co-workers have found that nitrate leaching in farming soil is the main reason of water pollution with nitrate in the ground [30]. According to Morrison, the nitrate contents of well water near villages were significantly cultivated areas and animal sources are considered to the major source [31]. Previously, nitrates in drinking water of southern Punjab, Pakistan was investigated and found that nitrates were higher in water of Bahawalpur and Bahawalnagar [32]. Iman *et al.* 2008 have studied the effective means for development of water management [33]. The analysis reveals that the surface and ground water in the study area of Attock City, Punjab, Pakistan needs also some degree of treatment before consumption [34].

In bore water the highest sulphate ions are found in sample 12B i.e.80.8mg/L and lowest ions are found in samples 19B i.e.15.2mg/L. Average value is found to be 35.4mg/L. All the value of sulphate ions are not exceeding the limits i.e. 250mg/L recommended by WHO. It means that ground water has no significant geological difference. In municipal water highest sulphate ions are present in sample 30M i.e. 85.2mg/L and lowest ions are in sample 29M i.e. 16mg/L. Average value of sulphate ions are 40.5mg/L. In river water sample the highest value of sulphate ions were found in sample 21R i.e.103.2mg/L and lowest value is found in sample18R i.e. 46mg/L. Average value of river water sample was found to be 66.06mg/L.

According to WHO standards the permissible limits for the Total dissolved solids (TDS) in drinking water is 500mg/L. The value observed in bore water sample it was found that the maximum value of TDS is 618.75mg/L i.e. exceeding from the limits and the lowest value was 276mg/L. Average value was found to be 405.2mg/L. In municipal water sample the minimum value was found in sample 22M i.e. 384mg/L and the maximum value is 509mg/L. In river water sample the minimum value is 323.75mg/L and the maximum value is 459.7mg/L. Average value is found to be 350.47 mg/L.

Dissolve oxygen (DO) is a function of temperature, pressure, salinity and biological activity in water body [35]. In bore water the minimum value was DO 3.5mg/L and the maximum value was 4.15mg/L. Average value was found to be 3.97mg/L. In municipal water supply the minimum value of DO 3.13mg/L and the maximum value is 4.18mg/L. In river water the minimum value of DO 4.16mg/L and the maximum value is 6.57mg/L. Average value is found to be 6.12mg/L.

Water Quality Index (WQI) was calculated for 90 samples. For this purpose the recent Water Quality Data of Patnaik and co-workers has been utilized [36]. In the present study samples were analyzed for 6 water quality parameters i.e. (1) pH (2) TDS (3) DO (4) NO3 (5) SO4 (6) Conductivity. Water quality parameters and water quality index are presented in Table 2A and Table 2B respectively.

The numerical of Water Quality Index (WQI), that water under consideration is fit for the human consumption if its WQI<100 and unfit for drinking without treatment if it's WQI>100 [37]. Moreover, the larger the value of WQI, the more polluted the water concerned. In all the 90% sample the WQI value is found to be high. 89 samples are having more than 100 and the one samples i.e. 4B (Bore water) has only one sample that is in the safe limits. The lowest WQI value is 96.03 and the highest value is 169.7. A close look at the original Water Quality data reveals that higher values of WQI at other sampling station are mainly due to higher values of nitrates in Attock City [38].

Clean and whole some drinking water is an essential requirement for a healthy life [39]. There are many potential sources of contamination with pathogens and toxic chemical and treatment of water has been involved to combat this threat [40]. The complexity of water pollution in surface and ground water is due to several processes occurring simultaneously like variation in the nature and flow rate of effluents, chains of reaction and their products. In this study the concentration of nitrate ions were above permissible level. The increasing concentration of these ions in water makes it unsuitable for domestic purposes but also for aquatic animals in rivers. No appreciable contamination of sulphates was observed in bore, municipal and river water.

Table 2A: Water quality parameters their standards and unit weights

Parameters	Standards	Unit Weight
pH	7.0 - 8.5	0.005
Nitrate	10mg/L	0.100
Sulphate	250 mg/L	0.004
TDS	500 mg/L	0.002
Conductivity	1000	0.001
DO	3 mg/L	0.333

Table 2B: Water quality index of bore, municipal and river water

Bore water	WQI	Municipal water	WQI	River water	WQI
1B	119.2	1M	128.7	1R	167.3
2B	117.3	2M	129.4	2R	158.8
3B	103.04	3M	129.1	3R	160.2
4B	96.03	4M	130.7	4R	160.6
5B	102.1	5M	131.4	5R	158.3
6B	107.3	6M	124.3	6R	129.7
7B	119.3	7M	122.3	7R	159.3
8B	106.8	8M	132.1	8R	169.7
9B	105.8	9M	130.4	9R	164.3
10B	107.5	10M	137.7	10R	160.1
11B	125.4	11M	142.1	11R	127.7
12B	135.4	12M	130.3	12R	167.2
13B	128.3	13M	130.7	13R	150.1
14B	126.2	14M	132.7	14R	163.1
15B	133.7	15M	131.7	15R	127.3
16B	154.6	16M	122.1	16R	165.7
17B	119.5	17M	134.7	17R	164.1
18B	103	18M	134.9	18R	153.3
19B	116.5	19M	130.7	19R	163.9
20B	148.7	20M	127.9	20R	169.6
21B	122.1	21M	130.1	21R	165.4
22B	115.1	22M	125.8	22R	164.1
23B	159.1	23M	125.7	23R	164.1
24B	118.1	24M	114.7	24R	160
25B	121.1	25M	109.2	25R	160.1
26B	121.5	26M	122.4	26R	160.3
27B	121.3	27M	125.5	27R	163.1
28B	144	28M	124.1	28R	159.8
29B	156.8	29M	120.2	29R	160.9
30B	130	30M	114.8	30R	162.1

In order to maintain the quality of surface and ground water it becomes rather imperative that following recommendation should be made and implemented as soon as possible. Investigation is required to establish the major sources of nitrate pollution in the region. More detailed sampling is required and the sampling period should be done in all the four seasons. To prevent further contamination of ground water in these effected areas, proper sewerage system and sewerage plant should be installed otherwise sewerage containing nitrogen will keep on seeping into ground water ultimately causing nitrate pollution. The pollutant sources which contribute to the Kabul River should be properly managed and proper sanitation system should be introduced in each and every village around the river. The recreation activities around the river should be restricted to defined areas. The visitors should not dump litter in the river [41].

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