Drinking Water Quality of Swat District

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Summary: Drinking water samples were collected from different localities of Swat District and *investigated for the physical and chemical parameters. The findings of the research work show that;* pH was 6.8-8.1, electrical conductivity was in the range of 0.001-0.43 mS, total hardness was 70-275 mg/ L, alkalinity as $CaCO_3$ was 58.8-347.9 mg/ L, Chloride was 4.5-35 mg/ L, sulphates was in the range of 3.45-6.54 mg/ L, nitrite was 0.00123 – 0.0086 mg/ L, nitrite was 0-4.55 mg/ L, Phosphate was 0.019 – 0.956 mg/ L and fluoride was 0.0012 – 0.0096 mg/ L. Iron was in the range of 0.1 – 0.956 mg/ L, copper 0.147- 0.780 mg/ L, manganese 0.123 – 0.463 mg/ L, sodium 1- 5.0 mg/ L and potassium 0 – 1.5 mg/ L. The values were compared with the standard of WHO and it was found that all parameters are within the permissible limit and hence cause no harmful effect to the human health.

Introduction

Water pollution is a global concern and is different in many respects. Water pollutants happen from many natural and anthropogenic actions. As well, water pollutants produced in one country may flow into other, producing a complex international problem. Water pollution can result from natural runoff, soluble chemicals in water that diffuse through the soil and man made sources; like farming, mining, building, manufacturing, homes and businesses. The pollution sources may be point sources or non-point sources. Point sources involve the release of waste from particular point including sewage treatment plants, storm water runoff from joint storm and sanitary sewer lines in city areas, manufacturing plants and animal feedlots. While the non-point sources involve the diffuse discharge of wastes from land runoff, atmospheric precipitation and sources of that which are difficult to recognize and control for example, runoff of residue from natural and human caused forest fires, building, logging and farming, effluents of chemical fertilizers, pesticides and saline irrigation water from croplands, urban storm water runoff, drainage of acids, minerals and sediments from active and dumped mines. Nonpoint source pollution is a big problem and is not recognize as a major problem because the sources are extensively spread out, hard to identify and tough to control.

The sustained survival of human being itself is a source of water pollution. In primitive era, the purifying potential of nature was much better than the rate of water pollution caused by human living. But with the passage of time, men began to settle close to water areas for the ease of living, and then they developed a variety of industries, which give them with the establishment of stylish life. Regularly, with the increase in the number of this industries/population the quality of water was contaminated, discharging a variety of wastes in to water bodies. Additionally, the increase in inhabitants has also invited the concentration of contamination sources. As a result, the rate of ecological pollution has improved the rate of natural decontamination [1] Previous studies have been conducted for the examination of various pollutants in the water and have also discussed their acute and chronic effects. Iqbal and Sultan, Mumtaz, Takeda, Sharma studied the pH of water of different sources respectively [2-5] Iqbal monitored chloride and fluoride in the domestic wastewater [6], nitrate was determined in different sources of water by different research workers [7–10]. Sulfate was also found by Ahmad [11]. Khawar and Bangash studied the metals in aqueous media [12–13]. District Swat is situated in the North-West of Pakistan is a fertile and beautiful area. It is located in latitude 34.09 °N

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through 35.56 °N and longitude 72.07 °N-E through 73.00 °E. The district is bounded by Gilgit and Chitral District in the north, Shangla at east, Buneer at south and Malakand agency and Dir at the West. Its population is about 1.249 million. Of which about 14 % is living in cities while remaining are living in villages. The total numbers of villages are 1246 with 145038 farm families. The purpose of this research work was to study the concentration of both physical and chemical parameters in the drinking water of Swat District and its contribution towards the environmental pollution.

Results and Discussion

Drinking water samples were collected from different regions of Swat Districts and were investigated for both physical and chemical parameters like pH, temperature, TDS, SS, TS, conductivity, total alkalinity, total hardness, NO_3^{-1}, Cl^{-1}, SO_4^{-2}, PO_4^{-3}, total coliform and some cations.

Table- 1 shows the pH of drinking water of Swat District is in the range of 6.8-8.1. Acid water is the one, which has a pH value of less than 7.0. Generally acidity in pure water is due to the presence of dissolved carbonic acid. Acidic water is extremely dangerous for living organisms and also for material objects like concrete pipes. It also increases the rate of solubility of heavy metals like copper, zinc and lead. The pH of the sample number 8 and 15 is slight acidic and show deviation from the recommended range *i.e.* 7.0 - 8.5 [1]. Therefore the water of these sites are not suitable for the drinking purpose. Conductivity is dependent upon the presence of ions in solution. The water samples of Swat District show conductivity from 0.001-0.43 *mS*, as shown in Table 2. These variations are due to the difference in the concentration of free ions like Ni^{++}, Na^{+}, Cl^{-1}. Similar results have also been reported by earlier workers [2]. Alkalinity is mostly due the presence of bicarbonates, carbonates, hydroxides and the basic radicals like calcium, magnesium, sodium and potassium. But alkalinity is often quoted as $CaCO_3$ instead of carbonates and bicarbonates. The samples collected at different localities of Swat District show alkalinity in different range and are given in Table 3, which is below than the recommended standard for drinking waters i.e. 500 mg/ L. Beyond this standard,

Table- 1: WHO standards for drinking water [1]

S. NO.	POLLUTANTS	PERMISSIVE	EXCESSIVE
1.0.	Physical:		
1.1	Turbidity (Units or Silica)	5 Units	25Units
1.2	Colour (Units On Platinum Cobalt Scale)	5 Units	25 Units
1.3	Taste and Odour	Nothing	Disagreeable
2.0	Chemical:		
2.1	pH	7.0-8.5	< 6.5 or > 9.2
2.2	Total Solids	500 mg/ L	1500 mg/ L
2.3	Total Hardness (as $CaCO_3$)	300 mg/ L	600 mg/ L
2.4	Calcium (as Ca^{+2})	75 mg/ L	200 mg/ L
2.5	Magnesium (as Mg^{+2})	50 mg/ L	150 mg/ L
2.6	Iron (as Fe^{+3})	0.3 mg/ L	1.0 mg/ L
2.7	Manganese (as Mn^{+2})	0.1 mg/ L	0.5 mg/ L
2.8	Copper (as Cu^{+2})	1.0 mg/ L	3.0 mg/ L
2.9	Zinc (as Zn^{+2})	5.0 mg/ L	15 mg/ L
2.10	Chlorides (as Cl^{-1})	250 mg/ L	1000 mg/ L
2.11	Sulphate (as SO_4^{-2})	250 mg/ L	400 mg/ L
2.13	Fluorides (as F^{-1})	1.0 mg/ L	2.0 mg/ L
2.14	Nitrates (NO_2^{-1})	20 mg/ L	50 mg/ L
3.0	Toxic Substance:		
3.1	Arsenic (as As^{+3})	0.2 mg/ L	0.2 mg/ L
3.2	Chromium (as Hexavalent)		0.05 mg/ L
3.3	Selenium (as Se^{+4})		0.05 mg/ L

Table- 2: Physico-Chemical parameters of drinking water samples of Swat district

S.No	Water source	Concentration (mg/ L)					
		pH	EC (*mS*)	Cl^-	TSS	TDS	TS
1	Stream water at Mingora	7.8	0.38	35	70	140	210
2	Stream water at Mingora	8	0.43	4.5	120	115	235
3	Stream water at Kokari	8.1	0.42	30	85	105	190
4	Spring water at Saidu	7.8	0.34	30	75	130	205
5	Swat River water	7.6	0.14	25	30	45	75
6	Canal water at Kanju	7.4	0.14	25	25	100	25
7	Stream water at Hazara	7.8	0.14	20	25	10	35
8	Well water at Bandai	6.8	0.34	30	80	150	230
9	Tap-water (MCS) at Mingora	7.8	0.001	25	105	100	105
10	Tube-well water at Mingora	7	0.23	25	245	50	295
11	Tap-water at Mingora	7.8	0.25	25	170	30	200
12	Tube-well water at Mingora	7.8	0.27	20	70	65	135
13	Canal water at Kabal	7.2	0.32	20	0	115	115
14	Canal water at Mingora	7	0.26	15	60	150	210
15	Canal water Bandai	6.8	0.27	20	35	105	140
	Mean	7.51	0.26	23.3	79.6	80.6	160.2
	SD	0.44	0.118	7.32	62.7	54.8	117.5
	CV (%)	5.88	45.2	31.45	78.7	68.0	146.7

problems like hardness, gastrointestinal irritation, kidney stone and explosion of metallic pipes due the accumulation of scales inside, are the most common [2]. Total hardness is mainly due to the presence of carbonates of calcium and magnesium. Total hardness determined in the samples and is given in table- 3. All samples show hardness which is below the maximum limit (500 mg/ L) recommended by W.H.O [1]. Beyond this limit, hardness may cause gastric problems, dehydration, gas trouble, kidney stone and heart problems [2].

Chlorides in water bodies are mostly present in combination with sodium, calcium and magnesium. Its concentration varies with the physiological and biological actions. Chlorides make its routes through natural mineral rocks, seawater, irrigation discharge, or from industrial effluents. Mostly, all types of water reservoirs contain chlorides less than 50 mg/ L (variations occur according to the weather) and exceeding this level indicate the probable pollution. Table- 2 shows the chlorides concentration in the drinking water of Swat District in the range of 4.5-35 mg/ L, whereas the permissible level for drinking purpose is 250 mg/ L. Thus all samples have chloride concentration within the permissible range. At high concentration i.e. above 250 mg / L, chloride can cause toxic effects [1, 2].

Nitrate in water in the oxidized form of nitrogen and is achieve by nitrifying bacteria. The extensive uses of synthetic nitrogenous fertilizers for the high yield of crops have increased the nitrate concentration in surface as well as in ground water. The concentration of nitrates in surface water is changeable and depends upon the seasonal fluctuations, which are related to the activity of microbes, as nitrates concentration is greater in winter season, compared to summer. Water containing high quantity of nitrates are extremely toxic to infants because the bacteria in the digestive system convert the nitrates to nitrites which then diffuse in the blood stream and change the oxygen transporter haemoglobin into methaemoglobin. Also the ingested nitrites react with the secondary and tertiary amines found in certain foods, form nitrosamines that are potentially carcinogenic. In our samples the nitrate level found was 0–4.55 mg/ L (Table- 4), while the maximum permissible level for drinking water is 50 mg/ L. The high concentration of nitrates may be dangerous and can cause the above-mentioned lethal effects [1, 2]. Sulphates in surface and ground water comes from the dissolution of mineral deposits containing sulphides, thiosulphates and sulphates like pyrites. Sulphates in domestic wastewater contribute to permanent hardness. High concentration of sulphates impart

Table- 3: Physico-Chemical parameters of drinking water samples of Swat district

S.No	Water source	Concentration (mg/ L)				
		TH	TH as $CaCO_3$	TH as $MgCO_3$	TA	MA
1	Stream water at Mingora	220	145	75	347.9	323.4
2	Stream water at Mingora	250	150	100	225.4	215.6
3	Stream water at Kokari	215	130	85	210.7	205.8
4	Spring water at Saidu	160	115	45	151.9	147
5	Swat River water	70	45	25	107.8	107.8
6	Canal water at Kanju	70	40	30	68.6	68.6
7	Stream water at Hazara	80	40	40	78.4	78.4
8	Well water at Bandai	160	110	50	132.3	127.4
9	Tap-water (MCS) at Mingora	80	50	30	58.8	58.8
10	Tube-well water at Mingora	100	80	20	98	98
11	Tap-water at Mingora	145	85	60	117.6	117.6
12	Tube-well water at Mingora	125	75	50	127.4	127.4
13	Canal water at Kabal	175	100	75	156.8	156.8
14	Canal water at Mingora	155	90	65	147	147
15	Canal water Bandai	125	85	40	117.6	117
	Mean	142	89	52.6	143.1	139.8
	SD	56.9	36	23.5	73.36	67.4
	CV (%)	40.1	40	44.6	51.27	48.2

Table- 4: Physico-Chemical parameters of drinking water samples of Swat district

S.No	Water source	Concentration (mg/ L)					
		F^{-1}	NO_2^{-1}	PO_4^{-3}	SO_4^{-2}	NO_3^{-1}	MPN
1	Stream water at Mingora	0.0012	0.0085	0.019	4.64	0	2
2	Stream water at Mingora	0.0023	0.0056	0.019	4.75	2.8	4
3	Stream water at Kokari	0.0024	0.00523	0.019	6.38	1.4	2
4	Spring water at Saidu	0.0056	0.0023	0.050	6.54	0.35	2
5	Swat River water	0.0078	0.0024	0.019	3.45	5.6	17
6	Canal water at Kanju	0.0089	0.0056	1.363	3.83	1.05	2
7	Stream water at Hazara	0.0074	0.0084	0.019	4.26	1.4	4
8	Well water at Bandai	0.0041	0.0086	0.113	5.40	4.55	14
9	Tap-water at Mingora	0.0025	0.0061	0.019	3.77	0.7	<2
10	Tube-well water at Mingora	0.0058	0.0032	0.019	4.91	0	<2
11	Tap-water at Mingora	0.0096	0.00314	0.050	4.37	0	2
12	Tube-well water at Mingora	0.0063	0.00564	0.550	4.04	3.5	6
13	Canal water at Kabal	0.0032	0.00254	0.050	3.55	2.45	9
14	Canal water at Mingora	0.0031	0.00256	0.019	5.08	4.9	17
15	Canal water Bandai	0.0065	0.00123	0.300	4.91	3.85	14
	Mean	0.00345	0.00472	0.175	4.66	2.17	-
	SD	0.00014	0.00021	0.350	0.93	1.92	-
	CV (%)	0.00025	0.00030	205.6	20.0	8.88	-

taste and when combined with sodium or magnesium result into laxative effect. Table 4 shows the quantity of sulphate in the selected area, which are in the limits 3.45–6.54 mg/ L, whereas its maximum concentration limit with regard to health is 400 mg/ L. The determined concentration is thus below the optimum concentration. When the sulphates concentration exceed that of the recommended level, then laxative and corrosive mode of action results [2].

The Phosphate concentration was noted in the range of 0.019-1.363 mg/ L as can be seen from table 4. No standard was recommended for phosphate by health authorities. Phosphates are mainly responsible for the process of eutrophication, which results in depletion of water and eventually the water body turns into swamps and marshes [14].

Table 4 show the fluoride concentration in the range of 0.0012 to 0.0096 mg/ L. The optimum concentration for fluoride given by W.H.O is 1.5 mg/ L [1]. Thus all samples have fluoride concentration with in the permissible range. However beyond the optimum concentration fluoride cause both acute and chronic toxicity such as mottling of teeth, skeletal fluorosis, forward bending of vertebral column, deformation of knee joints and other parts of the body, and paralysis [2].

The concentration of nitrite in our samples was noted in the range 0.00123-0.0086 mg/ L as can be seen from table 4. The permissible range for nitrite according to FWPCA is 0.021-1.25 mg/ L [15].

The coliform groups (MNP) were determined in the samples and are given in the table 4. The WHO standard is 10 cell/ 100ml of water. Our data shows that only 3 samples are above the permissible level therefore may be dangerous for human health [16].

Sodium is present in all natural water in abundance. The presence of sodium in water depends upon the anions present in that system and the temperature. The threshold taste concentration of sodium varies from compound to compound for example, for sodium chloride it is about 350 mg/ L (138 mg/ L as Na^{23}), whereas for sodium sulphates is 1000 mg/ L (as 348 mg/ L sodium). The leaching of sodium from their respective rocks is less as compared to other metal. As can be seen from the Fig. 1, the sodium concentration is 1-5 mg/ L, which is below the maximum threshold levels as recommended by health agencies. The high concentrations of sodium impart taste to the water and make it unfit for every day use [15].

Potassium is an important micronutrient for plants and human beings, playing an important role in the metabolism processes of animals. The highest permissible concentration of potassium in drinking water with respect to health is 20 mg/ L [2], above

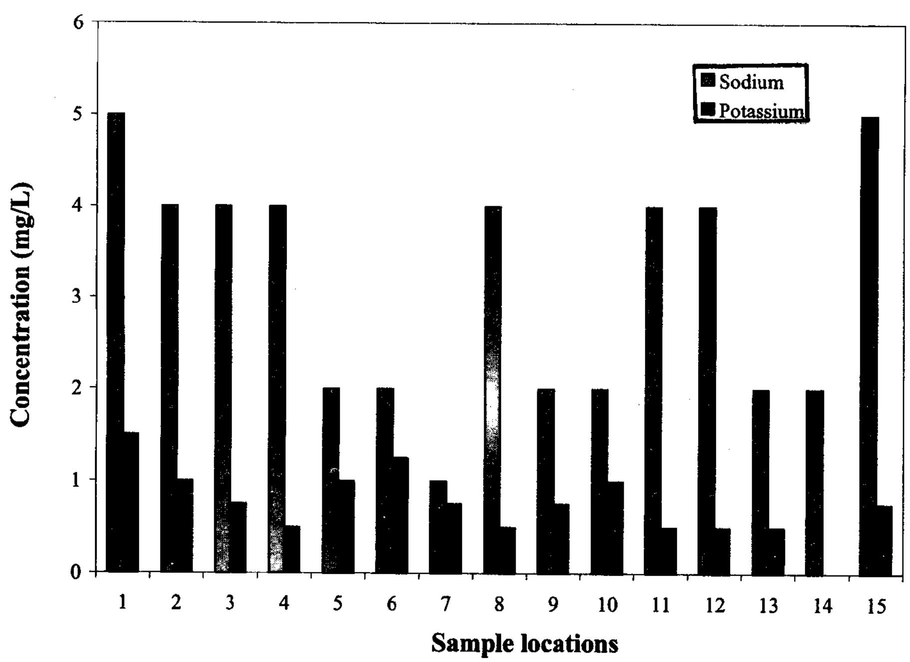

Fig. 1. Concentration of sodium and potassium in the drinking water of Swat district.

Table- 5: Physico-Chemical parameters of drinking water samples of Swat district

S.No	Water source	Concentration (mg/ L)				
		Na^{+1}	K^{+1}	Cu^{+2}	Fe^{+3}	Mn^{+2}
1	Stream water at Mingora	5	1.5	0.34	0.245	0.1759
2	Stream water at Mingora	4	1	0.265	0.246	0.1751
3	Stream water at Kokari	4	0.75	0.546	0.122	0.1657
4	Spring water at Saidu	4	0.5	0.480	0.111	0.1753
5	Swat River water	2	1	0.562	0.284	0.159
6	Canal water at Kanju	2	1.25	0.785	0.951	0.123
7	Stream water at Hazara	1	0.75	0.156	0.751	0.356
8	Well water at Bandai	4	0.5	0.456	0.956	0.289
9	Tap-water at Mingora	2	0.75	0.780	0.100	0.463
10	Tube-well water at Mingora	2	1	0.147	0.210	0.252
11	Tap-water at Mingora	4	0.5	0.258	0.101	0.147
12	Tube-well water at Mingora	4	0.5	0.753	0.213	0.123
13	Canal water at Kabal	2	0.5	0.452	0.315	0.148
14	Canal water at Mingora	2	0	0.452	0.245	0.145
15	Canal water Bandai	5	0.75	0.151	0.210	0.125
	Mean	3.1	0.75	0.0824	0.042	0.0425
	SD	1.3	0.36	0.0101	0.020	0.011
	CV (%)	4.15	48.7	0.0123	0.0145	0.0452

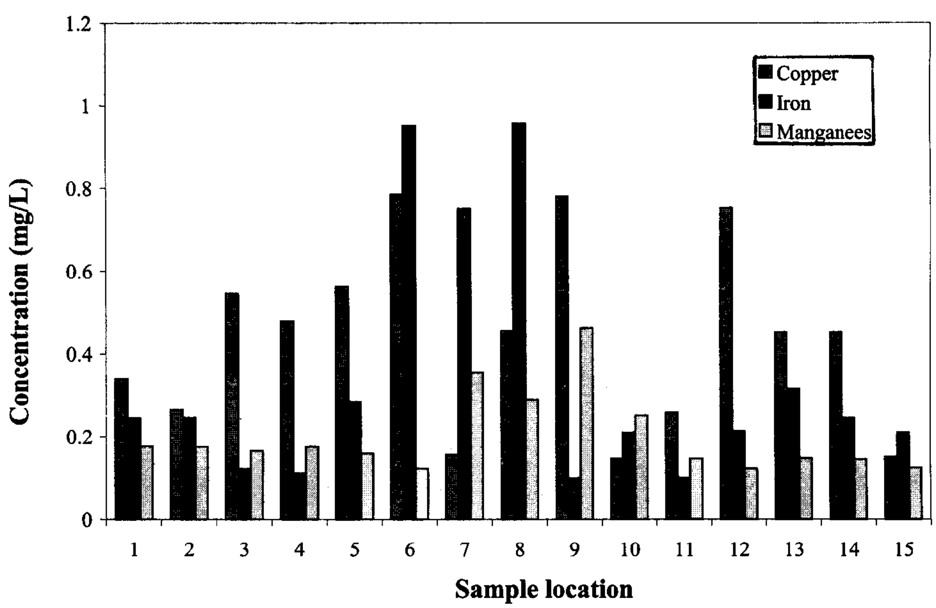

Fig. 2. Concentration of copper, iron and manganees in the drinking water of Swat district.

which it creating problems linked to sodium. Our samples show the concentration of potassium as, 0-1.50 mg/ L (Fig. 1). Therefore the drinking water of these sites may be tasty, leading to polluted water. These areas are actually over populated and thus result in the greater consumption and disposal of water (municipal sewage), thus adding greater pollutants to the surface and ground waters.

The concentration of copper was found to be in the range 0.147-0.780 mg/ L as can be seen from Fig. 2. The recommended value of NEQS is 1.0 mg/ L.

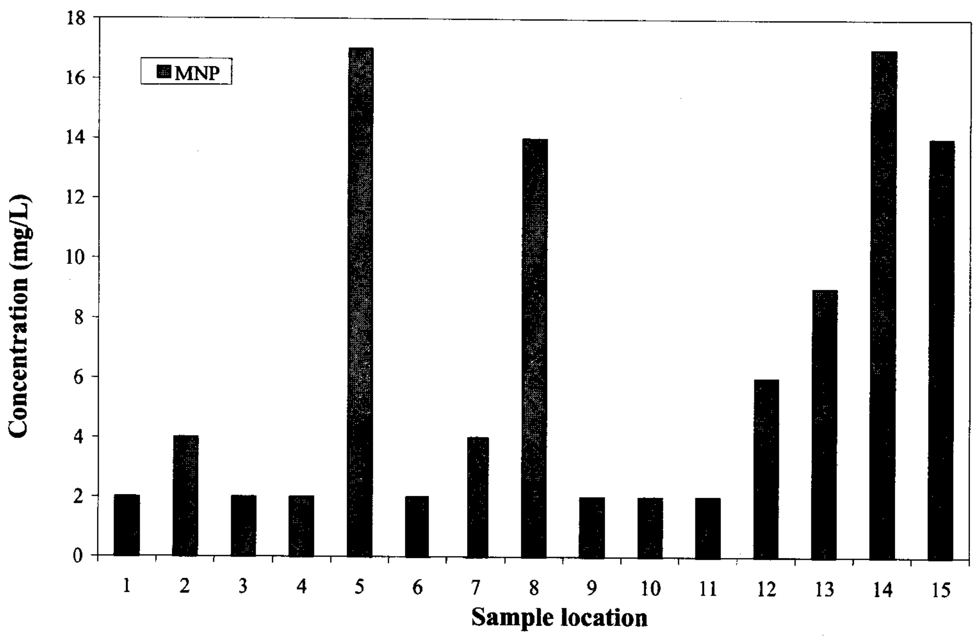

Fig. 3. Concentration of total coliform in the drinking water of Swat district.

As our values are below the recommended level therefore the water can produce no toxic effects. However above 3.0 mg/ L it can cause problems like gastroenteritis with nausea and haemochromatosis [2].

The manganese concentration varies from 0.123-0.463 mg/L (Fig. 2). The desirable value according to WHO is 0.5 mg/ L. All values are within the permissible limit. When the value exceeds 1.0 mg/ L then it can cause acute effects similar to Parkinson's disease.

Iron is generally present in trace amount in the drinking water in colloidal complex with other minerals or organic substances. Fig. 2 shows the total iron in the samples in the range of 0.1-0.956 mg/ L. Whereas the maximum limit according to WHO standards is 1.0mg/ L. Thus, the iron concentration, in all samples is below the limit (1.0 mg/ L) may cause coldness, restlessness, backache, rapid respiration and haemochromatosis [17].

Experimental

Water samples were collected from different localities of Swat district, in clean polyethylene bottles. Before taking the samples, the bottles were rinsed with the sample water and were then filled to overflow so that no air bubble was left trapped in the samples. Physical and chemical parameters like pH, conductivity, total alkalinity, total Hardness, Cl^{-1}, SO_4^{-2}, F^{-1}, NO_3^{-1}, PO_4^{-3}, Na^{+1}, K^{+1}, Ca^{+2}, Mg^{+2}, Cu^{+2}, and Fe^{+3}.

All the stock solutions were prepared with double distilled water and the reagent used were of analytical grade (Merck and BDH) without further purification. The instruments used were calibrated before each analysis. pH was measured, using pH meter (HI 8428, Hana)and conductivity by conductometer (PCM3-Jenway). Sulphate was determined by spectrophotometric methods [18]. Concentrations of Na^{+1}, K^{+1}, Ca^{+2}, Mg^{+2}, Mn^{+2}, Cu^{+2}, and Fe^{+3} Atomic Absorption spectrophotometer. For other parameters the following methods were used.

Total alkalinity

1. 0.02N H_2SO_4 solution.
2. Methyl Orange indicator.

Procedure

Five mL water samples was taken in the titration flask and 2-3 drops of methyl orange was

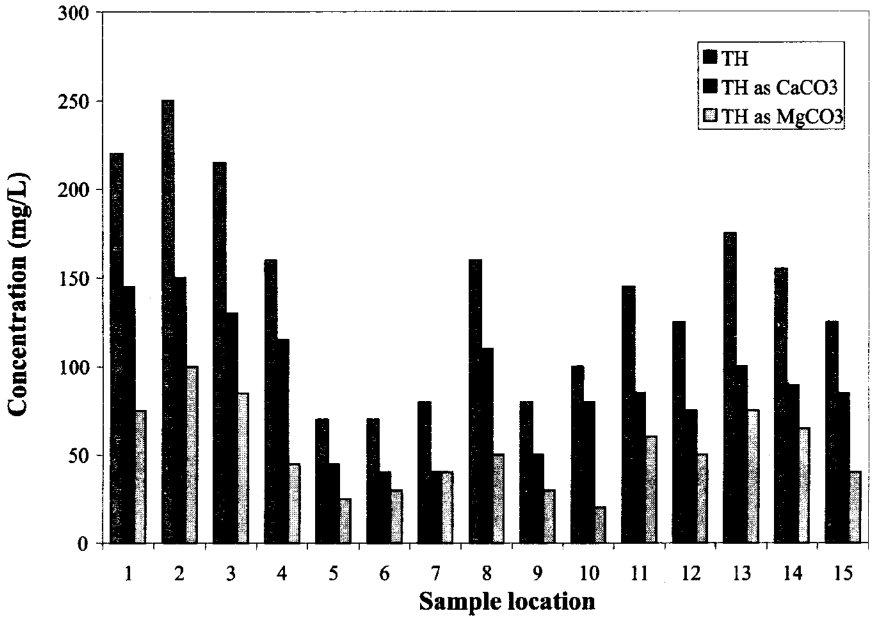

Fig. 4. Concentration of hardnessin the drinking water of Swat district.

added to it as an indicator and titrated against 0.02N H_2SO_4 solution. At end point color changed from yellow to reddish pink [19].

Calculations

$$\text{Total alkalinity mg/ L} = \frac{\text{ml of } H_2SO_4 \text{ x } 1000}{\text{ml of sample}}$$

Total Hardness

1. Buffer solution (pH = 10)
2. Indicator Erichrome–Black–T
3. 0.01 M EDTA standard solution.

Procedure

10mL of the water sample was taken in the titration flask. Then 1 – 2 ml of buffer solution (pH = 10) was added. Then 1 – 2 drops of EBT indicator was added to the flask. Then this solution was titrated against 0.01M standardized EDTA solution from the burette, with constant shaking untill the colour of the solution becomes blue. Then calculation was done for total hardness [20].

Calculations

$$\text{Total hardness } (CaCO_3) \text{ mg/ L} = \frac{\text{Volumeof EDTA x } 1000}{\text{mL of watersample}}$$

Nitrate (NO_3^{-1})

1. Aniline solution (10 %).
2. Sulphanilic acid (1 %).
3. Sodium hydroxide solution (1 %).
4. Hydrazine sulphate solution (1000 ppm).
5. Standard stock Nitrate solution (1000 ppm).
6. Copper turnings.

Procedure

20ml of the sample was taken in a beaker. Then 2ml of 1% NaOH solution, 4ml of hydrazine sulphate solution and a few copper turnings were added to it. It was heated for 15 minutes on a water bath at 100 ^{0}C. To the resulting solution 2ml of sulphanilic acid, 6ml of aniline solution were added and heated for further 15 minutes on a water bath at 100 ^{0}C. This solution was then transferred to 100ml volumetric flask and diluted upto the mark with distilled water. The concentration of nitrate was then determined by uv-visible spectrophotometer.

Chloride (cl^-)

1. 0.014 N $AgNO_3$ standard solution.
2. K_2CrO_4 indicator.

Procedure

12.5 ml of sample was taken in a titration flask and few drops of K_2CrO_4 was added as an indicator. Then it was titrated against $AgNO_3$ solution untill the colour changes from pure yellow to pinkish [21].

Calculations

1 ml of $AgNO_3$ = 0.5 mg cl^- $mg/L = \frac{mgcl^- \times 1000}{\text{ml of sample}}$

Phosphate (PO_4^{-3})

1. H_2SO_4.
2. Abcorbic acid (0.1M)
3. Ammonium molybadate (AM).
4. Potassium antimonyl tertarate (PAT).
5. Mix reagent.
6. Standard stock phosphate solution.

Preparation of mix reagent

125 ml of 0.5N H_2SO_4 and 375 ml of ammonium molybadate were thoroughly mixed. Then 75 ml of ascorbic acid solution and 12.5 ml of PAT solution were added to it. The reagent was prepared as required as it does not keep for more than 24 hrs.

Procedure

About 10 ml of sample solution was taken in 25 ml calibration flask. Then 2 ml of mixed reagent was added to it and diluted to the volume of 12.5 ml with distilled water and mixed well. The concentration of phosphate was then determined by uv-visible spectrophotometer [18].

Fluoride (F^{-1})

1. Alizarin red solution.
2. Zirconyl red solution.
3. Standard stock fluoride solution.

Preparation of Alizarin red solution

0.75 g of 3–Alizarin sulphuric acid sodium salt (alizarin red solution) was dissolved in distilled in distilled water and then diluted upto 1000 ml.

Preparation of zirconyl red solution

0.354 g of Zirconyl chloride octahydrate was dissolved in 600ml of distilled water. Then 33.3 ml of sulphuric acid(conc) followed by 10 ml of HCl (conc) is added slowly. Then cooled and diluted to 1000 ml.

Procedure

10 ml of the sample was taken in a flask and 0.5 ml of alizarin red solution and 0.5 ml of Zirconyl red solution was added to it and left it for one hour. Then the concentration of flouride was then determined by uv-visible spectrophotometer [21].

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