Assessment of Pollutants and its Impacts on the Drinking Water Quality of Malakand Division, Pakistan

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(Received 9th May, 2002, revised 10th January, 2003)

Summary: The drinking water samples collected from different localities of Malakand division were chemically examined for pH, conductance, hardness, various anions such as Cl^{-1}, SO_4^{-2}, F^{-1}, NO_3^{-1}, cations like Na^+, K^+ and total iron. The values were compared with standards of various health agencies and all the parameters were found within the permissible limits. The toxic effect of these parameters has also been discussed.

Introduction

Comprising over 70% of the Earth's surface, water is the most important natural resource. Without water life is non-existent. Anthropogenic actions pollute water resources like rivers, lakes and oceans. The main sources of water pollution are, municipal, industrial and agricultural. Municipal water pollution consists of wastewater from homes and commercial establishments. For many years, the major objective of treating municipal wastewater was just to decrease its content of suspended solids, oxygen-demanding materials, dissolved inorganic compounds and injurious bacteria. In current years more pressure has been made on improving methods of elimination of the solid residues from the municipal treatment processes. The methods of treating municipal wastewater fall into three categories: primary treatment, including sand removal, screening, grinding, and sedimentation; secondary treatment, which oxidize the dissolved organic matter using biologically active sludge, which is then filtered off; In tertiary treatment advanced biological, chemical and physical methods such as adsorption is employed.

The impact of industrial effluents depends not only on their combined characteristics such as COD, BOD and SS, but also on inorganic and organic substances. Agriculture, including commercial livestock and poultry farming, is the source of many organic and inorganic contaminants in waters (both surface and ground). These pollutants include both residue from erosion cropland and compounds of phosphorus and nitrogen that partly originate in animal wastes and commercial fertilizers. Animal wastes are high in oxygen demanding material, nitrogen and phosphorus and they often port pathogenic organisms. Controlling measures involve settling basins for liquids, limited biological treatment in aerobic or anaerobic lagoons etc.

Ninety-five percent of all fresh water on earth is ground water. Ground water is found in natural rock formations called aquifers. Most of the population relies on ground water as a source of drinking water. In rural areas this figure is even higher. Eighty one percent of community water is dependent on ground water. Water quality is closely associated with water use and to the conditions of economic development. In industrialized countries, bacterial contamination of surface water caused serious health problems in city areas. The waterborne diseases have been eliminated in the developed world. Cholera and other similar diseases still occur with alarming frequency in the developing countries. Since World War II, the Khaleege-War, the Afghan-War and the origin of the "chemical age", the water quality have greatly been effected world over. Eutrophication of surface waters from human and agricultural wastes and nitrification of groundwater from agricultural practices has seriously affected major parts of the natural world. Acidification of surface waters by air pollution is a recent problem and threatens aquatic life in many area of the world. In developed countries, these general types of pollution have occurred sequentially with the result that most developed countries have successfully dealt with major surface water pollution. However, newly industrialized countries are now facing all these issues simultaneously. [1-9]

Earlier workers investigate various acidic and basic radicals in the drinking water as well as in other water sources (industrial effluents) and also discussed their toxicity. pH of water of different sources were

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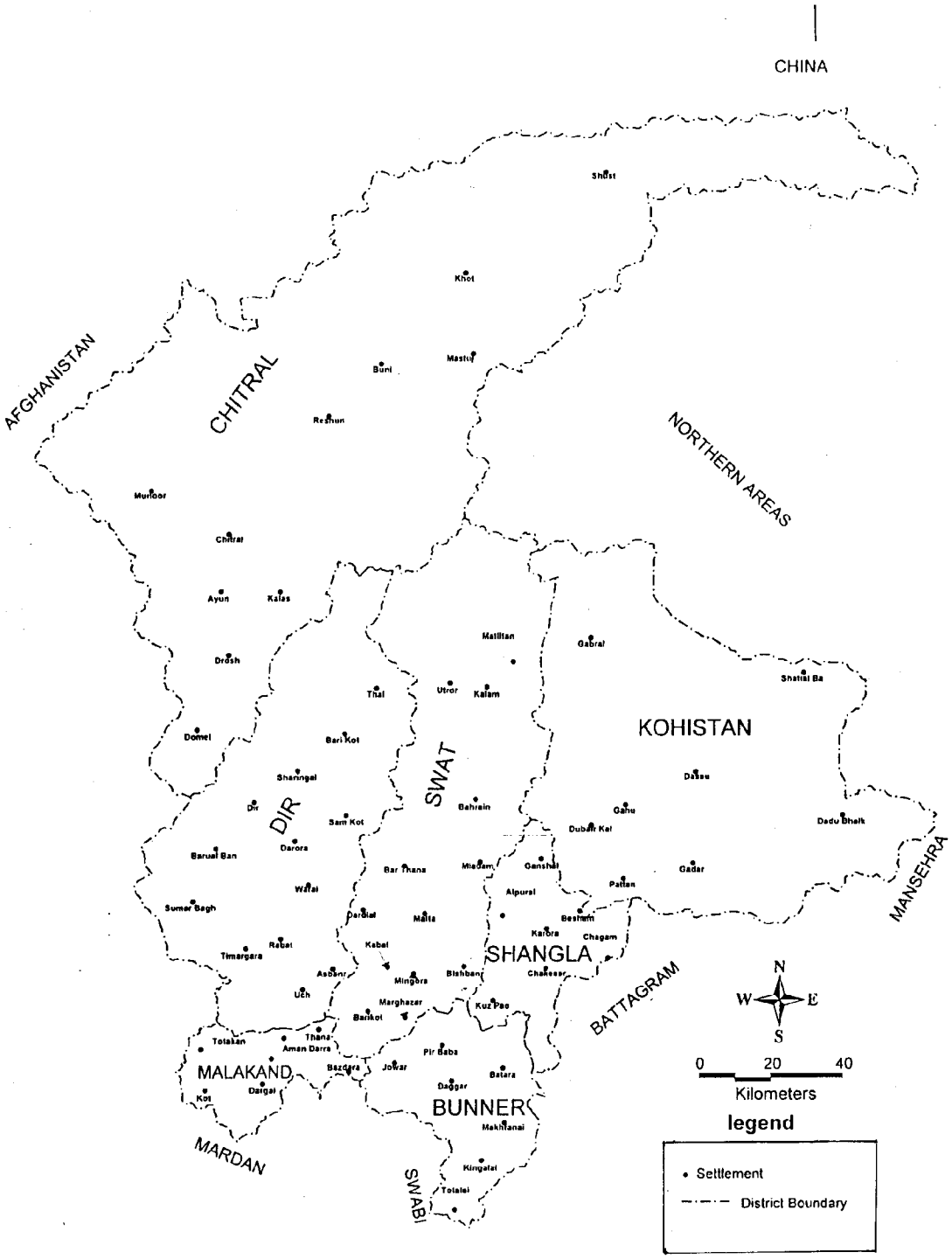
Map-1: THE DRINKING WATER SAMPLING AREAS OF MALAKAND DIVISION



also studied [10,11,12,13]. Vengosh [14] monitored chlorides and fluorides in the domestic wastewater. Nitrates were determined in different sources of water by different research workers [15-18] Sulfate was also found by Darie [19] Mumtaz and Khuhawar determined Sodium in the wastewater [12, 20], Gutekunst *et al* [21] studied the heavy metal in various media and Potassium in water of different sources [12, 20]. The drinking water quality forecast of Peshawar valley on the basis of sample data and aesthetic quality evaluation of drinking water of Peshawar valley have been studied by F. K. Bangash and S. Khan [29,30].

The present study deals with the assessment of pollutants and its impacts on the drinking water quality of Malakand Division, PAKISTAN and their contribution towards the physical health of living organisms. The physical geography of Malakand Division Include Bunner, Malakand Agency, Shangla, Swat, Kohistan, Dir and Chitral Districts. The area is located from 34° and 25′ to 36° and 55′ North latitudes and 71° and 12′ to 73° and 57′ East longitudes. Mardan and Swabi Districts cover the area in the south, Mansehra and Battagram in the southeast, Northern areas of Pakistan in the northeast, Afghanistan in the west and China in the extreme north (Map-1).

Results and Discussion

Drinking water samples were collected from different localities of Malakand Division and were analyzed for various parameters like pH, conductivity, total Hardness, Cl^{-1}, SO_4^{-2}, F^{-1}, NO_3^{-1}, Na^{+1}, K^{+1} and Total Iron.

pH refer to a scale of strength of acidity or alkalinity which is regarded as a measure of concentration of H^+ ions in water. pH of natural waters is nearly seven, however it is generally over 7.0 due to the presence of enough concentration of carbonates. It gets increased during day to a great extent due the process of photosynthesis (consumption of carbon dioxide) while increase at night because of respiratory activity. Factors like exposure to air, temperature and discharge of polluted water [21] (Both industrial and municipal wastewater), change the pH of water. It is evident from the graph. 1, that the pH of drinking water of Malakand Division was in the range of 7.23-7.93, which is within the recommended range of W.H.O i.e. 7-8.5. However at high concentration it may cause, burns in the mouth, esophagus and stomach with pain, nausea and vomiting. Inhalation cause coughing, burning in the throat, choking sensation, inflammation of the nose, throat, eyes and the digestive disorders in the human beings [22].

Table 1: Symbols Used for the Samples Collected at Different Locations.

S. No.	Drinking Water (Location)	Symbols For Samples.
1	River Swat at Amandara (M.A)	A
2	Tube Well at Amandara (M.A)	B
3	Timargara River (Dir)	C
4	Tube Well at Timargara (Dir)	D
5	River Swat at Haji Baba (Swat)	E
6	Tube Well at Haji Baba (Swat)	F
7	Spring at Malakand	G
8	Chitral River (Chitral)	H
9	Tube Well at Chitral (Chitral)	I
10	G.T Road Mingora	J

Nomenclature

S	=	Standard deviation.
mg/L	=	Milligram per liter
μ	=	Micro
WHO	=	World Health Organization.
μc/ml	=	Micro curie per milliliter
T.H	=	Total Hardness
S.L	=	Sample Locations
Cond.	=	Conductance
M.A	=	Malakand Agency

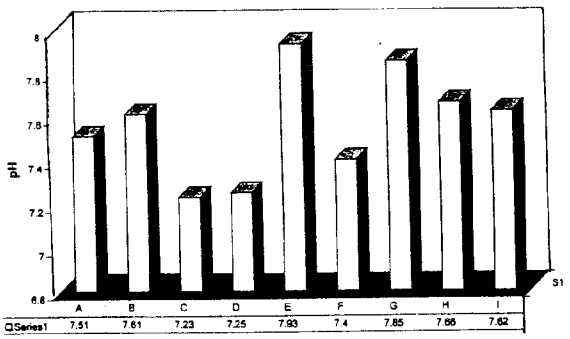


Fig. 1: Assessment of pH in the Drinking Water of Malakand Division, Pakistan

Conductivity is the measurement of the ability of a solution to carry electric current. Conductivity is temperature dependent. Fig.-2 shows conductivity of all the drinking water samples that vary from 0.159-0.446 μS/cm. These variations are due to the difference in concentration of free ions like Na^+, K^+, Cl^{-1}. Similar results have also been reported by earlier investigators [23].

Total hardness mainly accounts for the concentration of carbonates and is expressed, as

Table-2: Standard Deviation (S) for Assessment of Pollutants and its Impacts on the Drinking Water Quality of Malakand Division, Pakistan.

SL	pH	Cond.	T. H	Cl^{-1}	NO^{-1}_3	SO^{-2}_4	F^{-1}	$Fe^{+2,+3}$	Na^{+1}	K^{+1}
A	0.0008	0.000000	800	00	0.00045	800	0.00000	0.000075	008	50
B	0.0200	0.000008	200	20	0.00020	002	0.00000	0.00052	000	02
C	0.0200	0.000200	000	00	0.00000	050	0.00002	0.000000	200	00
D	0.0200	0.000000	800	50	0.000008	050	0.00000	0.00000	800	50
E	0.0008	0.000200	500	00	0.000002	000	0.00000	0.00000	018	08
F	0.0800	0.001013	200	00	0.00000	000	0.00000	0.00000	000	2288
G	0.0200	0.000200	500	20	0.00050	3200	0.00000	0.00089	008	00
H	0.1250	0.000000	000	20	0.00000	800	0.00000	0.000000	200	32
I	0.0040	0.000200	500	00	0.000200	000	0.00000	0.000000	000	00

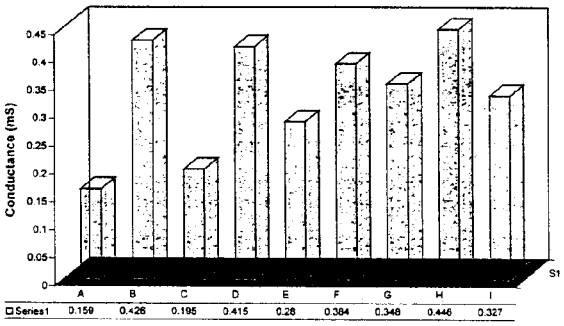


Fig. 2: Assessment of Conductance in the Drinking Water of Malakand Division, Pakistan.

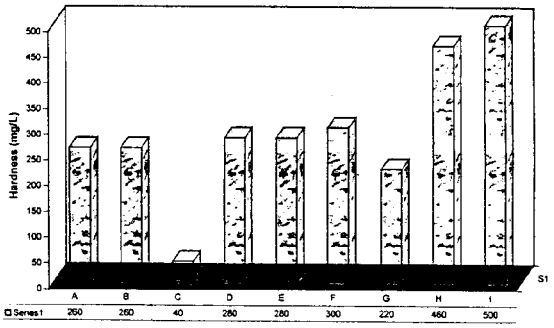


Fig. 3: Assessment of Total Hardness in the Drinking Water of Malakand Division, Pakistan.

$CaCO_3$ mg/L. Total hardness determined was in the range of 40-500 mg/L as shown in Fig.-3. All samples show a desirable level of hardness whereas the suggested level according to W.H.O is 500 mg/L. Hardness beyond this limit, may cause diarrhea, dehydration, gas trouble, kidney stone and cardiovascular disease, as reported by several research workers [25].

In natural fresh water high concentration of chlorides is regarded as a sign of pollution due to natural mineral deposits, agricultural or irrigation discharges, or from sewage and industrial effluents. Chlorides contents above 250mg/L make water salty in taste; however, a level up to 1000mg/L is safe for human consumption [24]. The concentration of chloride in the drinking water of Malakand Division varies from 12.5 to 29.19 mg/L., which are within the suggested range and as such cause, no side effects. However in excessive concentrations, may cause heart and kidney diseases [25].

In water, the most significant source of nitrate is the biological oxidation of nitrogenous organic matter of both autochthonous and allochthonous origin. Domestic and agricultural runoffs have been

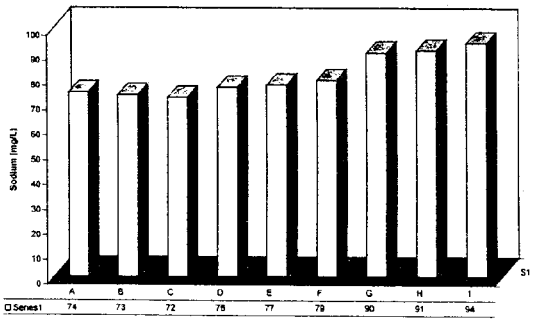


Fig. 4: Assessment of Sodium in the Drinking Water of Malakand Division, Pakistan.

considered as the main source of allochthonous nitrogenous organic matters. Metabolic waste of aquatic community and dead organisms add to the autochthonous nitrogenous organic matter. The nitrifying bacteria such as Aminifying, Nitrosomonas and Nitrobactor, play a noteworthy role in oxidation of such organic matter. In ground water nitrates enter through the leaching of soil and also by contamination. The concentrations of nitrates in the collected samples were noted to be in the range of

Table 3: Standards for Drinking Water [14]

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
2.12	Phenolics Substances (as Phenol)	0.0001 mg/L	1.0 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	Cyanides (as CN^{-1})		0.01 mg/L
3.4	Lead (as Pb^{+2})		0.1 mg/L
3.5	Selenium (as Se^{+4})		0.05 mg/L
4.0	Radio Activity:		
4.1	Alpha Emitter (μc/ml)		10^{-7}
4.2	Beta Emitter (μc/ml)		10^{-7}

0.02-0.04 mg/L. The highest permitted limit for nitrates is 50 mg/L [26] above this level it may cause ever-present growth of algae and blue-baby disease in other plants. In humans it may cause confusion, vertigo, weakness, yellow vision, clammy skin cardiovascular collapse, shortness of breath on exertion and trapping of blood in the veins of lower extremities etc [25].

Fluoride is usually more frequent in ground water than in surface water. The sources of fluoride are fluoride-bearing rocks. The utmost acceptable limit of fluoride in the drinking water according to W.H.O is 1.5 mg/L [24]. The concentration of fluorides in the drinking water of Malakand is in the range of 0.001-0.004 mg/L, as can be seen in Fig.-9, which is below the recommended limit, hence it causes no health effects. However at high concentration it may result mottling of teeth, skeletal fluorosis, forward bending of vertebral column, deformation of knee joints and other parts of the body, and paralysis [24].

Sulphate occurs in concentration sufficient in all natural water, particularly high arid and semi-arid regions where natural waters contain high quantities of salts. Domestic and industrial sewage have low

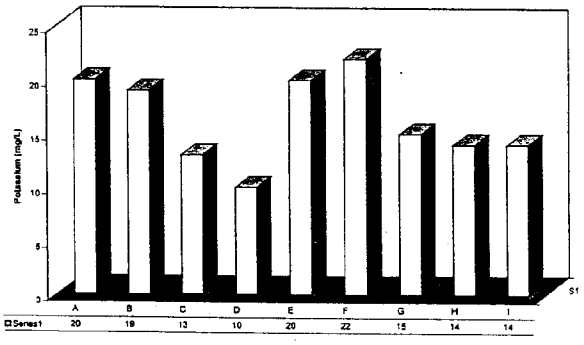


Fig. 5: Assessment of Potassium in the Drinking Water of Malakand Division, Pakistan.

quantity of sulphate due to the biological activity of microorganisms. Fig.-8 shows the concentration of sulphate in the range of 15-50 mg/L. whereas the highest allowed limit is 400mg/L. The results for sulphate contents of the drinking water of Malakand Division are blow this level, thus is safe for drinking. High concentrations of sulphate may however cause diseases like intestinal disorders [24].

The concentration of sodium is usually high in saline and brackish water. This high concentration limits the biological diversity due to osmotic stress.

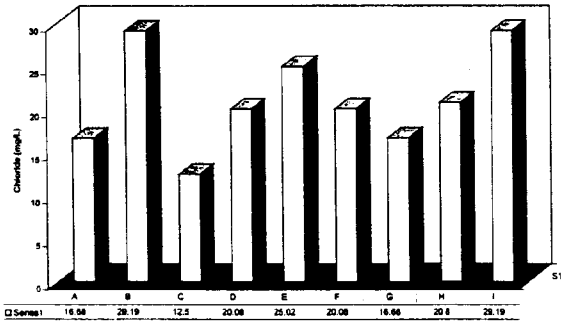


Fig. 6: Assessment of Chloride in the Drinking Water of Malakand Division, Pakistan.

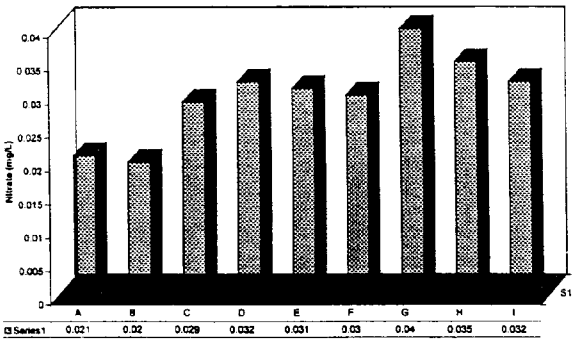


Fig. 7: Assessment of Nitrate in the Drinking Water of Malakand Division, Pakistan.

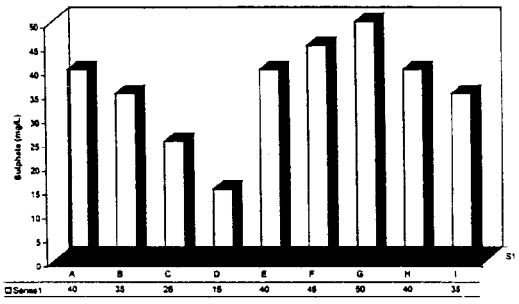


Fig. 8: Assessment of Sulphate in the Drinking Water of Malakand Division, Pakistan.

Salts of sodium are highly soluble in water and results into softness in comparison with hardness. Fig.-4.0, shows the amount of sodium in the drinking water of Malakand Division, which exist in the range of 72-94 mg/L. Sodium in the form of sodium chloride and sodium sulphate is highly soluble and make the water salty in taste and thus unfit for human consumption. High sodium contents in water causes puddling of soil, making it hard for the germination of seed [24].

In natural water the potassium is found in far smaller concentration than other metals. It acts in the water as sodium does, although it occurs in small concentration but plays an important role in the metabolism of freshwater environment and is regarded to be a vital macronutrient [21]. As can be seen from Fig.-5, the amount of potassium in the samples under investigation was in the range 10-22 mg/L, which is lower than the permissible limit i.e. 20mg/L [26].

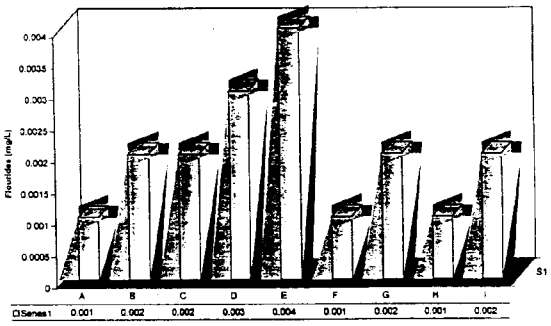


Fig. 9: Assessment of Flourides in the Drinking Water of Malakand Division, Pakistan.

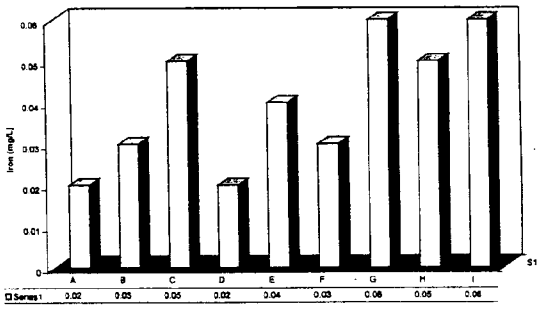


Fig. 10: Assessment of Iron in the Drinking Water of Malakand Division, Pakistan.

Iron occurs in all natural water, both in oxidized (ferric) as well as in ferrous forms. In ground water, typically it is found in ferrous state. Ferric iron is an important plant nutrient. The maximum permissible limit of iron for drinking water is 1 mg/L [21]. In the drinking water of Malakand Division total iron determined was in the range of

0.02-0.06 mg/L, which is within the recommended range. At high concentration iron may cause diseases like vomiting, weakness, pale face, coldness, restlessness, backache, rapid respiration etc [24].

Experimental

Drinking water samples were collected from source and consumption points from different localities of Malakand Division, in clean poly-ethylene 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. pH and conductance were noted at the sampling point. Afterward the bottles were stored in refrigerator. Physical and chemical parameters such as pH, conductivity, total hardness, nitrates, chloride and some cations were investigated in the samples.

pH was measured, using pH meter and conductivity by conductometer. Total hardness was determined by titration with standard EDTA [27]. Chloride was investigated by volumetric method [28]. NO_3^{-1}, SO_4^{-2} and F^{-1} were determined spectrophotometrically [28,24]. Concentrations of sodium and potassium were measured by Flame-Photometer. Iron was determined by Atomic Absorption spectrophotometer.

Standard Deviation

The standard deviation for the sample data was calculated using the following formula [23].

Standard Deviation:

$$S = \sqrt{\Sigma (xi - \bar{x})^2/n}$$

Whereas

S = Standard derivation
xi = Individual number
$\bar{x}$ = Mean
n = Total number

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