ISSN-1996-918X

Pak. J. Anal. Environ. Chem. Vol. 14, No. 2 (2013) 51 – 57

Physico-Chemical Analysis of Groundwater and Agriculture Soil of Gambat, Khairpur District, Pakistan

Tajnees Pirzada[1*], Mir Munsif Ali Talpur[1], Yasmeen Faiz Qazi[2] and Shahid Naseem[3]

[1]*Department of Chemistry, Shah Abdul Latif University Khairpur, Sind, Pakistan*
[2]*Department of Microbiology, Shah Abdul Latif University Khairpur, Sind, Pakistan*
[3]*Department of Geology, University of Karachi, Sind, Pakistan*

Received 01 April 2012, Revised 28 July 2013, Accepted 30 July 2013

Abstract

This study was conducted to estimate the ground water as well as agriculture soil quality, nutrient status and physico-chemical characteristics of Gambat, District Khairpur, Pakistan. Assorted parameters like temperature, pH, EC, TDS, Cl^-, SO_4^{2-}, HCO_3^-, sodium, potassium, calcium, magnesium, SAR values as well as the Piper and Stiff diagrams were determined to confer a clear picture of quality parameters in ground water and agriculture soil of the area. The present investigations conclude that the maximum parameters are not at the level of pollution except major metal ions Na^+ and Ca^{2+}. The higher concentration of Ca^{2+} and Na^+ could be due to the deposits of the salts of these elements into soil, which may had leached into ground water. The Piper diagram suggest that composition of water is (Na^++K^+)-$(Ca^{2+}+Mg^{2+})$-HCO_3^--$(Cl^- +SO_4^{2-})$-type. The areal distribution of stiff diagram constructed for groundwater samples showed ionic balances, indicating the major ion analyses are of good quality. Therefore, both ground water and soil samples observed are satisfactory for their utilization in various purposes such as domestic, agricultural, industrial, etc.

Keywords**:** Ground water; Agriculture soil; Physicochemical characteristics.

Introduction

This contemporary research in view of environmental quality is focused on water, owing to its significance in maintaining the human health as well as ecosystem. Fresh water is predetermined resource, important not only for agriculture and industrial purposes but also for human existence; sustainable development would not be possible without its ample quantity and quality [1-3]. The acquisition of various kinds of pollutants and nutrients into water bodies tends to alter the physicochemical characteristics of water [4-6]. Globally the rapid increase in the rate of degradation of the quality of water and soil is becoming a serious problem [7]. The composition of water may be affected by natural cause and man's cultural activities articulated as of measurable quantities, related to its usage. In the drainage basin, groundwater quality is affected by natural factors like hydrological, geological, biological, topographical and meteorological changes, which are altered with seasonal differences in runoff volumes, endure conditions and water levels [8]. All over the world, groundwater is an important source, which makes available livelihood to millions of people of the area. In Pakistan, groundwater is used intensively to sustain supply of drinking water for livestock, irrigation, industrial and many commercial activities [9,10]. It is usually not as much of vulnerable to contamination and pollution

*Corresponding Author Email: tajnees@yahoo.com

as surface water bodies [11]. Importantly, the naturally occurring sources of contamination are brought about during soil and geologic formation possessing elevated metal level that can leach into as well as rainwater impurities enter into the groundwater systems, which are deleted while infiltrating through soil strata [1, 9]. The fertilizers and pesticides widely used in crop growing season, when dispersed over large areas also contaminate it. Industrial effluents and municipal waste are discharged into the water bodies, ultimately penetrate into the soil. Remediation of such contaminations is very difficult, therefore prevention of water and soil resources has been focused, which have turn out to be dumping ground of domestic wastes and other refuge of the society due to the human activities [12]. These impurities may be categorized as biological, organic and inorganic chemicals, physical and radiological, which are responsible for the bad taste, color, odor or turbidity, hardness, corrosiveness, staining or frothing in water and in agriculture lands, they are responsible for salinity and sodicity [13,14].

Therefore, the knowledge about the status of groundwater and agriculture soil by estimating the extent of pollutants is vital in order to save these precious resources for future generation. This work is conducted to analyze pollution level in underground water and agriculture soil of Gambat, Distict Khairpur, Pakistan.

Materials and Methods

Experimental sites

Samples of the underground water and soil were collected in pre-cleaned polypropylene bottles from different localities around the Gambat, District Khairpur in the day time from the hand pumps or motor pumps at the depth of 40 – 50 feet. Sampling sites were 1. Khora, 2. Gambat, 3. Ripri, 4. Tando Masti, 5. Drib Mehar Shah, 6. Agra, 7. Jado and 8. Razidero.

Physico-chemical analysis

The physicochemical parameters of intense nature like pH, EC, temperature, color and odor were noted on the spot. The samples were taken to the laboratory and acidified with HNO_3 to pH <5 to minimize precipitation and absorption on the walls of container, [15] then different physical and chemical parameters were determined. All the chemicals used for the preparation of reagents and calibrations were of analytical grade. Analysis was conducted for the water and soil quality parameters, such as sulfates were estimated gravimetrically and chlorides by Mohr's Argentometric method, while carbonate-bi-carbonate determination was achieved by titration with 0.1N hydrochloric acid. Estimation of individual elements sodium, calcium, magnesium and potassium was carried out from digested salts obtained by evaporating water at 70 ^{0}C using Atomic Absorption Spectrophotometer Analyst 100 Perkin Elmer. The concentration of each element was estimated with reference to standard solution of the element.

The measured parameters were compared with the WHO standards and the data available elsewhere.

Results and Discussion

The variation in physico-chemical characteristics of water are graphically illustrated in the (Fig. 1). The temperature of water ranged from 23 ^{0}C to 25 ^{0}C, which is suitable for plant growth, i.e. 20-30 ^{0}C because, over 30^{o}C the retardation in growth and decay in plants occur. The data lies within the permissible limits, no health based guidelines have been recommended by WHO [16]. However, every 10 ^{o}C rise in temperature doubles the rate of biological activities and chemical reactions [17].

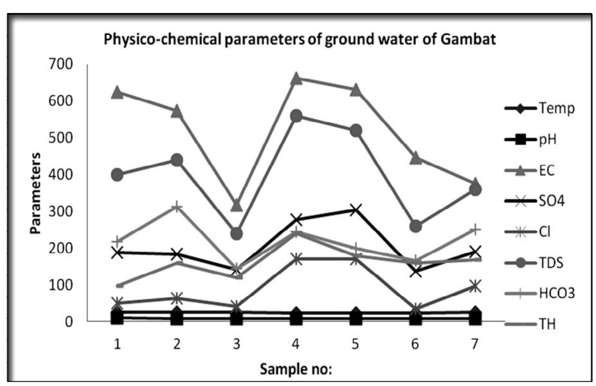

Figure 1. **Physico-Chemical parameters of ground water of Gambat**

Ideal water must not possess any odor. The odor of water is directly related to the temperature and considered to be due to the presence of substances with high vapor pressure, which stimulates the human sensory organs of smelling. Almost all samples were found to be odorless as no objectionable smell has been observed, which may be due to the presence of less amount of chemicals especially organic matter and indicative of reduced biological or industrial activity in the water or soil [18].

The pH of ground water ranged from 7.52 to 8.70 and soil 8-9. The higher values of pH of all soil and water samples indicated alkaline nature, soil pH >8 typically indicates the existence of sodium as salts. This may be attributed to application of fertilizer containing sulfate and phosphate to the soil, domestic discharges, photosynthesis or pesticides/insecticides used to increase the fertility of soil, which invariably contribute to higher pH values of water and soil [1,19].

TDS in water and soil originates from natural sources, sewage, urban and agriculture run-off, municipal wastes and chemical weathering of rocks [20]. The palatability of drinking water has been rated by panels of tasters in relation to its TDS level [21]. The TDS contents ranges between 240-560 mg/L. Ripri and Agra possesses lowest values <300 ppm that comes in the excellent class and Tando Masti, Drib Mehar Shah are good between 300-600 ppm, as per criteria given by Bruvold [21]. Water containing extremely low concentration of TDS may also be unacceptable because of its flat and inadequate taste [16].

The EC values in the water were found within the WHO specified limit except at Tando Masti area having maximum value 663µS/cm whereas, Ripri showed minimum EC values 318 µS/cm. The criteria of EC for irrigation water as suggested in literature [18] that the EC of water < 2 mS/cm is excellent for irrigation and crops production. Whereas, 4.0 mS/cm shows adverse effects on the health of the crops as less water is available to plants, which leads to the physiological drought [20].

The alkalinity of water is caused mainly due to hydroxyl, carbonate and bicarbonate ions. Alkalinity ranges between 144-312 mg/L, except Gambat and Razidero which possesses slightly higher values, therefore the quality of all water samples is acceptable.

Comparatively less values of chloride content were recorded throughout the area. Chloride level appeared in irregular manner, ranging between 34-170 mg/L, which is also lesser than the specified WHO level 250 mg/L; whereas Khora, Ripri and Agra have very low content of chloride <50 mg/L. It is commonly found in irrigation water, its high concentration causes toxicity to sensitive crops. In this study, very less concentration of Cl^- is observed hence; the water is beneficial for plants growth. Generally from the aspect of Cl^-, water with less than 70 mg/L Cl^- is considered to be safe for all plants and an indication of the good quality of water for drinking purposes. The increasing degree of eutrophication enhances Cl^- level in the water [22,23].

Sodium is the dominant cation, which varies between 168.1-265.9 mg/L (Table 1). All the ground water samples fall within the WHO recommended guideline values of 200 mg/L except Tando Masti. Whereas, in all other soil samples, the Na^+ was found high, ranging between 433-736 mg/kg (Table 2). Higher Na^+ percentage in the water may be attributed to the soil sodicity [24].

Table 1. **Major elements in ground water (mg/L) and soil (mg/kg) of Gambat.**

Sample #	Ca^{2+}		Mg^{2+}		Na^+		K^+	
	Soil	*Water*	*Soil*	*Water*	*Soil*	*Water*	*Soil*	*Water*
1.	461.38	104.48	116.82	30.38	633.41	187.3	27.94	5.35
2.	438.5	105.08	119.61	37.75	732.2	202.83	29.12	8.05
3.	395.38	94.5	125.5	33.7	533.8	170.82	40.58	7.28
4.	352.25	61.19	127.46	59.77	433.62	265.9	25.04	6.69
5.	338.5	83.48	110.11	28.22	620.56	175.6	28.85	8.55
6.	347.37	132.2	116.19	39.02	515.55	168.1	32.04	7.84
7.	329.5	124.1	123.61	48.18	598.38	201.48	41.43	9.41
8.	322.87	122.63	120.13	45.51	714.36	190.75	37.35	9.68

Table 1 shows the potassium content, ranging between 5.35-9.68 mg/L. 100% samples of ground water are within the WHO recommended limits. Whereas all other soil samples of the area are rich in K^+, i.e. 25.94-41.43 mg/kg. High K^+ contents in soil may be attributed to the application of K^+ fertilizers to increase the crop yields and K^+ is also released from dead plants and animal excrements [23].

The range of calcium concentration in water samples found slightly higher (61.19-132.2 mg/L) but within the permissible limits. Ca^{2+} is directly related to hardness, higher Ca^{2+} contents increase hardness in water and make it unsuitable for domestic as well as agriculture purposes. The amount of Ca^{2+} in all the soil samples is higher, i.e. 269.9-497.3 mg/kg may be due to passage of water through deposits of limestone [1, 25].

The range of Mg^{2+} in all the ground water samples observed within the safe limits, i.e. 28 to 59.7 mg/L except slightly higher value shown by Tando Masti. Mg^{2+} is a constituent of most of agriculture fertilizers. Mg^{2+} containing materials applied to soil serve as a nutrient and as $MgCO_3$ to neutralize soil acidity. The soil samples were found rich in Mg^{2+} contents shown in Table 1, i.e. 110-127 mg/kg. Higher values of Mg^{2+} could be attributed to the presence of geochemical strata [1,23,25] too.

SAR is also a measure of sodium hazard for irrigation [26]. In all the samples SAR value found to be less than 10 therefore; it is considered excellent for irrigation. The range of SAR values 7.12-10.63 (Table 2) show the excellent quality of soil for agriculture. The range of SAR of ground water is 3.31 to 6.08 (Table 2).

Table 2. **Ratio of Na in water (mg/l) & Soil (mg/kg).**

Sample#	Na^+%		SAR		pH	
	Soil	*Water*	*Soil*	*Water*	*Soil*	*Water*
1.	58.35	53.8	10.10	4.16	9.0	8.70
2.	59.69	57.6	10.39	4.32	10.0	7.75
3.	57.45	52.9	8.49	3.85	9.0	7.52
4.	62.88	48.2	7.12	6.08	9.9	7.60
5.	62.14	56.5	10.63	4.27	9.4	7.99
6.	54.16	50.7	8.64	3.31	8.9	7.76
7.	58.53	54.9	10.15	3.9	9.8	7.8
8.	62.92	54.3	12.25	3.78	10.2	8.08

To promote the research, interrelationship studies between different variables is helpful tool, which reduces the range of uncertainty related to decision making. The correlation coefficient analysis was done by using SPSS statistical tools and the data was illustrated in Table 3, in which pH do not show any correlation with all parameters, *i.e.* TDS, Cl^-, SO_4^{2-}, HCO_3^-, Ca^{2+}, Mg^{2+}, Na^+ and K^+. On the other hand, very strong correlation of EC with TDS, SO_4^{2-} and SO_4^{2-} with TDS and Cl^- was found. Positive values of ‘r’ designate the relationship exist among the ions, which varies together and water is of the same nature and source, while the different nature, source and behavior is reflected by the negative values of ‘r’[27].

Table 3. **Correlation coefficient among the physicochemical parameters of ground water of Gambat.**

	pH	**EC**	**TH**	**Cl^-**	**TDS**	**SO_4^{2-}**	**HCO_3^-**	**Ca^{2+}**	**Mg^{2+}**	**Na^+**	**K^+**
pH	1.00										
EC	0.39	1.00									
TH	-0.77	-0.15	1.00								
Cl^-	-0.12	0.55	0.52	1.00							
TDS	0.12	0.87	0.52	0.84	1.00						
SO_4^{2-}	0.03	0.73	0.27	0.93	0.91	1.00					
HCO_3^-	0.14	0.30	0.00	0.25	0.45	0.13	1.00				
Ca^{2+}	-0.02	-0.45	-0.33	-0.58	-0.66	-0.63	-0.24	1.00			
Mg^{2+}	-0.42	0.14	0.63	0.46	0.37	0.25	0.34	-0.18	1.00		
Na^+	-0.26	0.49	0.52	0.46	0.67	0.51	0.35	-0.49	0.90	1.00	
K^+	0.80	0.48	-0.62	-0.15	0.17	0.05	-0.05	-0.12	-0.07	0.14	1.00

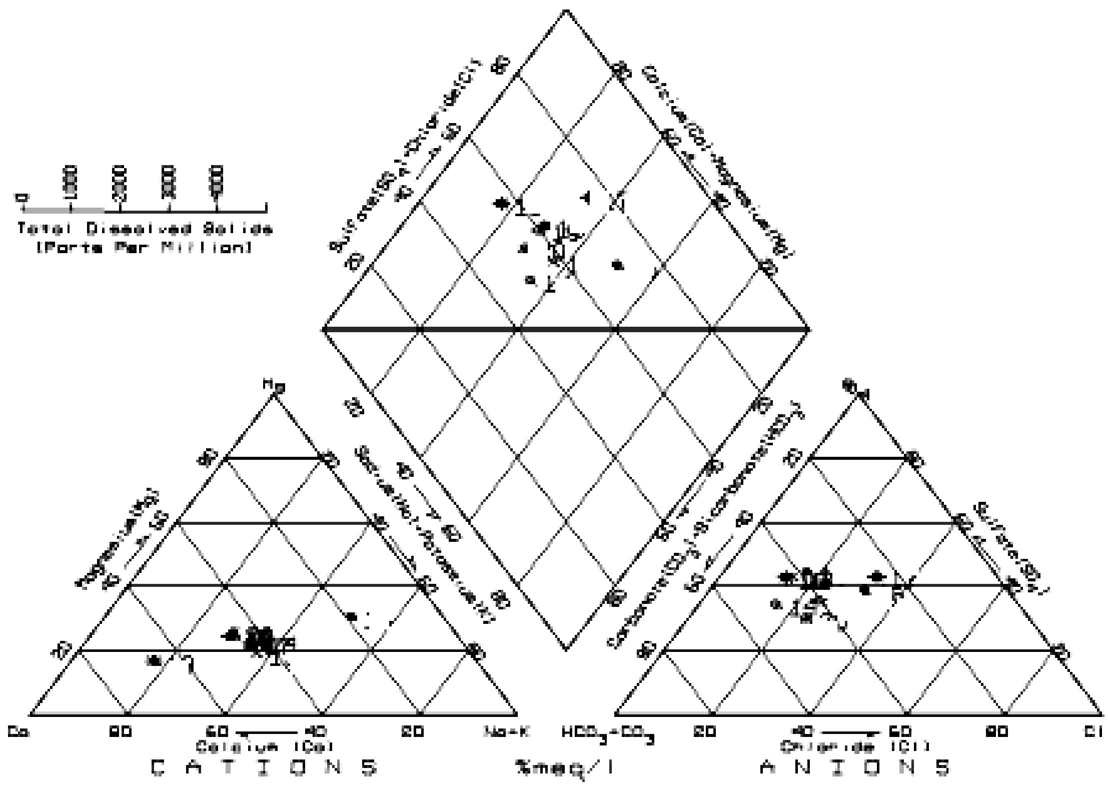

Figure 2. **Piper Diagram of ground water of Gambat**

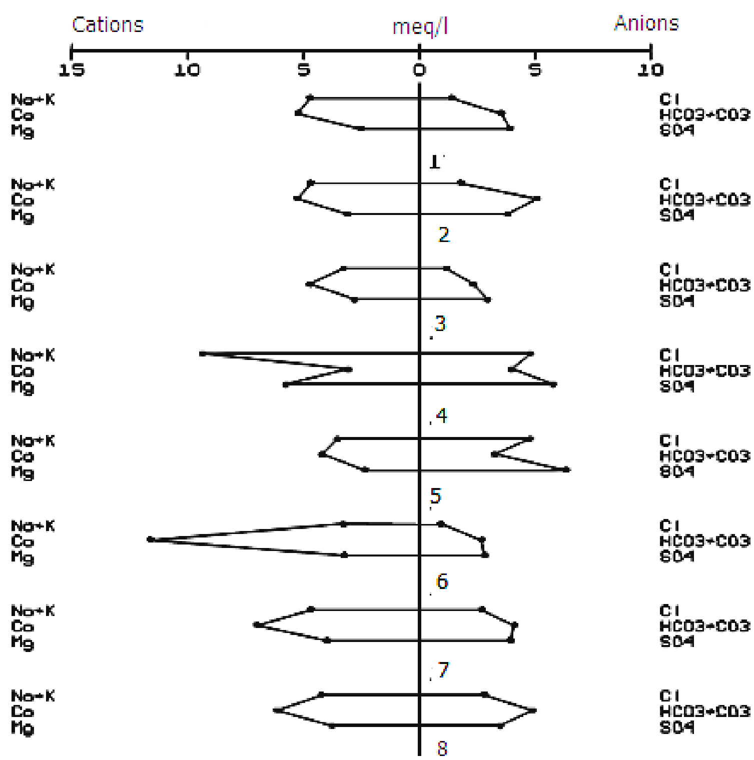

Figure 3. **Stiff Diagram of ground water of Gambat**

All the groundwater samples except Tando Masti, Ripri are $(Na^{+}+K^{+})$-$(Ca^{2+}+Mg^{2+})$-HCO_3^{-}-$(Cl^{-} + SO_4^{2-})$-type. The samples show wide spread in the anion trilinear diagram sample Tando Masti is $(Ca^{2+}+Mg^{2+})$-HCO_3^{-}-type and Ripri is $(Ca^{2+}+Mg^{2+})$ -$(Cl^{-}+SO_4^{2-})$-type. It is apparent from this analysis (Fig. 2) that 70% samples reflect a mixed type composition being in the center of the diamond. All the samples varying between alkaline earth to alkaline water and have Na^{+}-Ca^{2+}-SO_4^{2-} and Na^{+}-Mg^{2+}- HCO_3^{-} composition. $Na^{+}+K^{+}$ is the dominant ions which may be attributed to partly anthropogenic and partly natural conditions such as ion exchange or natural water softening with the local clay minerals, thereby enriching these waters with Na^{+}-HCO_3^{-} [28].

The areal distribution of stiff diagram constructed for water samples (Fig. 3) demonstrated ionic balances, indicating the major ion analyses are of good quality. The parameters on Stiff diagrams agreed with the above mentioned water facies type in Piper diagrams. The type is referred to as $(Na^{+}+K^{+})$-$(Ca^{2+}+Mg^{2+})$-HCO_3^{-}-$(Cl^{-}+SO_4^{2-})$-type.

Conclusion

By this study the quality of ground water and soil of Gambat was assessed and compared with the international standards. Certain parameters like temperature, pH, total suspended solid, total dissolved solid, alkalinity, chloride, sodium, potassium, calcium and magnesium were estimated. The present investigations conclude that the maximum parameters are not at the level of pollution except major metal ions Na^{+} and Ca^{2+}. The higher concentration of Ca^{2+} and Na^{+} could be due to the deposits of the salts of these elements into soil, which may had leached into ground water. The Piper diagram suggest that composition of water is $(Na^{+}+K^{+})$-$(Ca^{2+}+Mg^{2+})$-HCO_3^{-}-$(Cl^{-}+SO_4^{2-})$-type. The areal distribution of stiff diagram constructed for groundwater samples showed ionic balances, indicating the major ion analyses are of good quality. Therefore, both ground water and soil samples observed are satisfactory for their utilization in various purposes.

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