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

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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⁻, SO₄²⁻, HCO₃⁻, 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 Ca²⁺. The higher concentration of Ca²⁺ 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⁺)-(Ca²⁺+Mg²⁺)-HCO₃⁻-(Cl⁻+SO₄²⁻)-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

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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, District 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,

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 HNO₃ 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
gavimetrically and chlorides by Mohr’s
Argentometric method, while carbonate-bi-
carbonate determination was achieved by titration
with 0.1N hydrochloric acid. Estimation of
individually elements sodium, calcium, magnesium
and potassium was carried out from digested salts
obtained by evaporating water at 70 °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 °C to 25 °C, which is suitable for plant
growth, i.e. 20-30 °C because, over 30°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 °C rise in
temperature doubles the rate of biological
activities and chemical reactions [17].

![Figure 1. Physico-Chemical parameters of ground water of Gambat](image-url)
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 wast waters 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
560 mg/L. Ripri and Agra have very low content of sodium as salts. This may be attributed to irrigation water, its high concentration causes toxicity to sensitive crops. In this study, very less concentration of Na+ was observed hence; the water 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.

<table>
<thead>
<tr>
<th>Sample #</th>
<th>Ca2+</th>
<th>Mg2+</th>
<th>Na+</th>
<th>K+</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>461.38</td>
<td>104.48</td>
<td>116.82</td>
<td>30.38</td>
</tr>
<tr>
<td>2.</td>
<td>438.5</td>
<td>105.08</td>
<td>119.61</td>
<td>37.75</td>
</tr>
<tr>
<td>3.</td>
<td>395.38</td>
<td>94.5</td>
<td>125.5</td>
<td>33.7</td>
</tr>
<tr>
<td>4.</td>
<td>352.25</td>
<td>61.19</td>
<td>127.46</td>
<td>59.77</td>
</tr>
<tr>
<td>5.</td>
<td>338.5</td>
<td>83.48</td>
<td>110.11</td>
<td>28.22</td>
</tr>
<tr>
<td>6.</td>
<td>347.37</td>
<td>132.2</td>
<td>116.19</td>
<td>39.02</td>
</tr>
<tr>
<td>7.</td>
<td>329.5</td>
<td>124.1</td>
<td>123.61</td>
<td>48.18</td>
</tr>
<tr>
<td>8.</td>
<td>322.87</td>
<td>122.63</td>
<td>120.13</td>
<td>45.51</td>
</tr>
</tbody>
</table>
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>
<thead>
<tr>
<th>Sample#</th>
<th>Na(^+) (\text{Na}%)</th>
<th>SAR</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>Water</td>
<td>Soil</td>
<td>Water</td>
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<tr>
<td>1.</td>
<td>58.35</td>
<td>53.8</td>
<td>10.10</td>
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<tr>
<td>2.</td>
<td>59.69</td>
<td>57.6</td>
<td>10.39</td>
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<tr>
<td>3.</td>
<td>57.45</td>
<td>52.9</td>
<td>8.49</td>
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<td>4.</td>
<td>62.88</td>
<td>48.2</td>
<td>7.12</td>
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<td>5.</td>
<td>62.14</td>
<td>56.5</td>
<td>10.63</td>
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<td>6.</td>
<td>54.16</td>
<td>50.7</td>
<td>8.64</td>
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<td>7.</td>
<td>58.53</td>
<td>54.9</td>
<td>10.15</td>
</tr>
<tr>
<td>8.</td>
<td>62.92</td>
<td>54.3</td>
<td>12.25</td>
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</table>

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

<table>
<thead>
<tr>
<th>Sample#</th>
<th>Na(^+) %</th>
<th>SAR</th>
<th>pH</th>
</tr>
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<tbody>
<tr>
<td>Soil</td>
<td>Water</td>
<td>Soil</td>
<td>Water</td>
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</table>

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

<table>
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<tr>
<th></th>
<th>pH</th>
<th>EC</th>
<th>TH</th>
<th>Cl</th>
<th>TDS</th>
<th>SO(_4^{2-})</th>
<th>HCO(_3^-)</th>
<th>Ca(^{2+})</th>
<th>Mg(^{2+})</th>
<th>Na(^+)</th>
<th>K(^+)</th>
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<tr>
<td>Samples</td>
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<td></td>
<td>1.00</td>
<td>0.39</td>
<td>-0.77</td>
<td>-0.12</td>
<td>0.12</td>
<td>-0.03</td>
<td>0.14</td>
<td>-0.02</td>
<td>-0.42</td>
<td>-0.26</td>
<td>0.80</td>
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\[\text{pH}\]
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⁺)-(Ca²⁺+Mg²⁺)-HCO₃⁻-(Cl⁻ + SO₄²⁻)-type. The samples show wide spread in the anion trilinear diagram sample Tando Masti is (Ca²⁺+Mg²⁺)-HCO₃⁻-type and Ripri is (Ca²⁺+Mg²⁺)-SO₄²⁻-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⁺-Ca²⁺-SO₄²⁻ and Na⁺-Mg²⁺- HCO₃⁻ 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⁺- HCO₃⁻ [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⁺)-(Ca²⁺+Mg²⁺)-HCO₃⁻-(Cl⁻ +SO₄²⁻)-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 Ca²⁺. The higher concentration of Ca²⁺ 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⁺)-(Ca²⁺+Mg²⁺)-HCO₃⁻-(Cl⁻+SO₄²⁻)-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.

References