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# Studies on hydro chemical characters of ground water in Sabratha region

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**Abstract**
Assessment of Chemical components in ground water used for drinking and irrigation purposes in Sabratha region were carried out. Samples were collected from 30 wells supplying drinking and irrigation water to the inhabitants in the region. All samples were analyzed for 20 parameters (PH), TDS, Conductivity, Salinity %,SO4 $^{--}$,Cl$^-$,T.H (CaCO3),Ca. as CaCO3,Mg. CaCO3,Alkalinity, HCO3-,NO2-,NO-3,NH4$^+$,Ca $^{++}$,Mg$^{++}$,PO4$^{++}$,T, Na$^+$, K$^+$,Fe recording (7.3145, 1067.015, 3.86%, 271.5275, 323.515,687.4435, 0.5565,129.996,75.523,0.457,0.1035,0.111,165.9015,71.7785, 1.13935,46.386, 161.8925,3.964, 0.281) respectively. On the other hand, HCO3, NO-3, NH4+,Ca ++ and, Mg++ recorded an acceptable pi index values for standard quality with (0.251743, 0.0023, 0.074, 0.829508 and,0.478523). All studied parameters recorded a positive correlation coefficient values (r) with the well depth except turbidity and NO$^-_3$ with (-0.40595 and -0.44572 respectively). The mean molar ratios for (Na$^+$/Cl$^-$,Ca$^{2+}$ /Mg$^{+2}$, Na$^+$/K$^+$, Ca$^{2+}$/SO4$^{+2}$,Mg$^{+2}$/Cl- and HCO3$^-$/Cl$^-$) recorded (0.498159 ± 0.21546, 2.495585 ± 0.812503, 31.62218 ± 31.84079, 1.02488 ± 1.443147, 0.204791± 0.151537 and, 3.960664 ± 3.259324) while r values for the former molar ratios and the well depth recorded (0.015584, -0.07644, 0.084268, -0.02134, 0.276538 and 0.336213).
**Conclusion**: HCO3, NO-3, NH4$^+$,Ca $^{++}$ and, Mg$^{++}$ recorded an acceptable pi index values for standard quality with (0.251743, 0.0023, 0.074, 0.829508 and,0.478523). All studied parameters recorded a positive correlation coefficient values (r) with the well depth except turbidity and NO$^-_3$ with (-0.40595 and -0.44572 respectively). On the other hand, an acceptable molar ratios were recorded only for Ca$^{2+}$/SO4$^{+2}$ (1.02488 ± 1.443147). all estimated molar ratios recorded a psotive correlation coefficient values with the well depth except Ca$^{2+}$ /Mg$^{+2}$ and Ca$^{2+}$/SO4$^{+2}$ with (-0.07644 and, -0.02134). It is concluded that, an adequate and suitable treatment must be applied to the wells having elevated concentrations of the metals and supplying drinking water to the consumers.

**Keywords:** Chemical components, Groundwater, molar ratios, sources, Sabratha region

## 1. Introduction

Water is one of the most vital resources for the sustenance of human, plants and other living beings. It is required in all aspects of life and health for producing food, agricultural activity and energy generation. Groundwater is rarely treated and presumed to be naturally protected, it is considered to be free from impurities, which are associated with surface water, because it comes from deeper parts of the earth (Tiwari, *et. al,* 2012) [26].

The World Health Organization (WHO) has discriminated the major factor influencing the greater population is/as lack of access to clean drinking water (Njitchoua *et al.*, 1997) [19]. Poor quality of water adversely affects the human health, and plant growth (Hem, 1991, 1985; Karanth, 1997) [11, 10, 14]. The quality of water is vital owing to its suitability for various purposes since it is directly linked with human welfare. Groundwater quality variation is a function of physical and chemical patterns in an area influenced by geological and anthropogenic activities (Subramani *et al.*, 2005) [25].

The total quantity of water on earth is approximately14 trillion cubic meters. Trace elements are the important part of the material basis of medical effects (Mohammad *et al.,*2005) [17]. Heavy metals are among the most persistent pollutants in the aquatic ecosystem because of their resistance to decomposition in natural conditions (Khan., 2011) [13]. It has long been recognized that large area of the globe contains human population characterized by having trace elements deficiency, or excess including chronic poising. Sediments and suspended particles are also important repositories for trace metals, e.g Cr, Cu, Mo, Ni, Co and Mn (Javid Hussain *et. al.,* 2012). Groundwater condition in an aquifer depends on amount, duration, intensity of precipitation, depth of weathering, specific yield and general slope of

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formation toward drainage channels. Groundwater occurs in the weathered presidium under unconfined conditions as well as in the fractured rocks under semi confined conditions. The thickness of weathered layer irrespective of rock type ranges from 2.2 m to 50 m (Gopinath, 2011) [9]

In recent times, there has been an increasing health related concern associated with the quality of drinking water in developing countries. According to a recent report by WHO/UNICEF, about 780 million people in the developing world lack access to potable water due largely to microbiological and chemical contaminations (WHO/UNICEF 2012) [27]. Drinking water sources in these so-called developing countries are under increasing threat from contaminations by chemical, physical and microbial pollutants. Known sources (both naturally occurring and anthropogenic) of chemical contamination of water supplies include organic and inorganic substances from industrial effluents, municipal wastes, petroleum derived hydrocarbons, detergents, mining, agricultural pesticides and fertilizers (Ergul *et al* 2013) [7].

Groundwater quality gets altered when it moves along its flow path from recharge to discharge areas through the processes like: evaporation, transpiration, selective uptake by vegetation, oxidation/reduction, cation exchange, dissociation of minerals, precipitation of secondary minerals, mixing of waters, leaching of fertilizers, manure and biological process (Appelo and Postma, 1993) [2].

Trace metals, among a wide range of contaminants, are consistently of health concern due to their toxicity potentials at very low concentrations, and tendency to bioaccumlate in tissues of living organisms over time (Ikejimba and Sakpa 2014) [12].

Although several studies have assessed the groundwater quality based on heavy metal pollution for different purposes, there are only a few studies that targeted the abundant of the major chemical components of the ground water. In the present investigation we studied a large number of chemical components and properties of ground water in Sabratha region in western Libya.

## Materials and Methods
**Study Area:** Ground water samples were collected from wells (n=30) located in Sabratha region. Samples were carried out to be examined in the laboratory. The location of the wells was recorded using Geological Positioning System (GPS). The sampled wells were a private property. Many of the sampled wells were the main source of drinking water for the local population.

## Collection of Samples
Ground water samples were collected in one-liter plastic bottles, which were previously thoroughly washed with tap water and rinsed with distilled water. These were immediately acidified to pH 2 with $HNO_3$ in order to keep metals in solution and prevent them from adhering to the walls of the bottles. All samples were transported to the laboratory in iceboxes and refrigerated at 4°C until analyzed. Sampling protocol was designed in such a way that samples collected in one sampling schedule were analyzed in the shortest possible time.

## Sample Analysis
Samples were analyzed for trace metals (PH), TDS, Conductivity, Salinity %,$SO_4^-$,Cl-,T.H ($CaCO_3$),Ca. as $CaCO_3$,Mg. $CaCO_3$,Alkalinity, $HCO^{-3}$,$NO^{-2}$,$NO^{-3}$,$NH_4^+$,Ca $^{++}$,$Mg^{++}$,$PO_4^{++}$,T, $Na^+$, K+, Fe using a Perkin Elmer model 1000 Inductively Coupled Plasma. (ICP) spectrophotometer equipped with an ultrasonic nebulizer model Cetec U 5000 AT. The use of the ultrasonic nebulizer instead of a pneumatic nebulizer provided a 5 to 50 fold improvement in detection limits and a 10 fold enhancement resulting in better reproducibility on trace metal level determinations. Analysis was carried out in triplicate and average values are reported. The ICP was calibrated with relevant Perkin Elmer Pe-Pure spectroscopy grade standards.

## Results and Discussion
The minimum, maximum and standard division of (trace, macro elements, salts, salinity, alkalinity, and PH) values in different parts of sabratha region has been estimated.

**Table 1:** Minimum, maximum, mean values and, standard division of samples

| Parameters | Minimum | Maximum | Mean | SD |
|---|---|---|---|---|
| )PH( | 8 | 5.91 | 7.3145 | 0.576308 |
| TDS | 81.9 | 5278 | 1067.015 | 1131.125 |
| Salinity % | 0.60% | 15.80% | 3.86% | 0.033414 |
| $SO_4^{--}$ | 6.8 | 1478.88 | 271.5275 | 334.1127 |
| $Cl^-$ | 26.9 | 1722 | 323.515 | 368.1234 |
| T.H ($CaCO_3$) | 33.33 | 2955 | 687.4435 | 707.9965 |
| Turbidity | 0.00 | 2.00 | 0.5565 | 0.71771 |
| Alkalinity | 19.89 | 232.66 | 129.996 | 72.11777 |
| HCO3 | 11.42 | 142.98 | 75.523 | 37.9325 |
| $NO_2^-$ | 0.02 | 1.99 | 0.457 | 0.456244 |
| $NO^-_3$ | 0.00 | 0.6 | 0.1035 | 0.179569 |
| $NH_4^+$ | 0.00 | 1.3 | 0.111 | 0.285194 |
| Ca $^{++}$ | 7.73 | 788 | 165.9015 | 185.6782 |
| $Mg^{++}$ | 3.56 | 365.95 | 71.7785 | 84.42492 |
| $P2O4^{++}$ | 0.027 | 7.88 | 1.13935 | 1.707537 |
| CO2 | 4.24 | 124.66 | 46.386 | 37.0481 |
| $Na^+$ | 4.9 | 989.55 | 161.8925 | 207.3451 |
| $K^+$ | 0.00 | 16.66 | 3.964 | 3.695867 |
| Fe | 0.00 | 1.1 | 0.281 | 0.264494 |

**Table 2:** Values of WHO for ground water quality

| Water quality parameter | (WHO) | PI Index | Classification |
|---|---|---|---|
| )PH( | 6.5-8 | 1.008897 | unacceptable |
| TDS | 1000 | 1.067015 | unacceptable |
| $SO_4$ -- | 250 | 1.08611 | unacceptable |
| $Cl^-$ | 250 | 1.29406 | unacceptable |
| T.H ($CaCO_3$) | 100 | 6.874435 | unacceptable |
| HCO3 | 300 | 0.251743 | acceptable |
| $NO^-_3$ | 45 | 0.0023 | acceptable |
| $NH_4^+$ | 1.5 | 0.074 | acceptable |
| Ca $^{++}$ | 200 | 0.829508 | acceptable |
| $Mg^{++}$ | 150 | 0.478523 | acceptable |
| $P2O4^{++}$ | 0.13 | 8.764231 | unacceptable |
| $Na^+$ | 200 | 0.809463 | unacceptable |
| $K^+$ | 30 | 0.132133 | unacceptable |
| Fe | 1.5 | 0.187333 | unacceptable |

As shown in fig (1) a positive correlation values were recorded between the depth of the well an all the parameters of the study except salinity. A possible explanation is that a great amounts of salts are abundant deeply in the ground and dissolved in the ground water. On the other hand, TDS, SO4--, TH ($CaCO_3$), $Ca^{++}$, $Cl^-$ and Mg $^{++}$ were higher than the standard levels recognized by (WHO2004) and (ISI 1995). A great variations between investigated values and standard ones are occurred in an important chemical components such as TDS, Mg $^{++}$ and TH ($CaCO_3$) so, the current study shed light on a potentially vital problem. Groundwater is under pressure in many parts of the world, especially in arid and semiarid regions. It is important to develop methods that reduce the complexity of data to clearly understandable numbers that managers and decision makers can readily use. These results are in agreement with those of (Nash and McCall, 1995) [18] who stated that, efficiency in water use, water re-use, groundwater recharge and ecosystem sustainability. Groundwater catastrophe is controlled by both natural and human actions. The World Health Organization (WHO) has discriminated the major factor influencing the greater population is/as lack of access to clean drinking water.

**Table 3:** Correlation coefficient values and regression equations for chemical components and the well depth

| Parameters | r | Regression equations |
|---|---|---|
| )PH( | 0.226406 | y = 0.009x + 6.8386 |
| TDS | 0.415038 | y = 32.462x - 645.35 |
| Salinity % | 0.380013 | y = 0.0009x - 0.0077 |
| $SO_4$ -- | 0.406895 | y = 9.4005x - 224.35 |
| $Cl^-$ | 0.385959 | y = 9.8245x - 194.73 |
| T.H ($CaCO_3$) | 0.421452 | y = 20.633x - 400.93 |
| Turbidity | -0.40595 | y = -0.0201x + 1.6192 |
| Alkalinity | 0.441146 | y = 2.1999x + 13.952 |
| HCO3 | 0.273061 | y = 0.7162x + 37.742 |
| $NO_2^-$ | 0.543734 | y = 0.0172x - 0.4479 |
| $NO^-_3$ | -0.44572 | y = -0.0055x + 0.3954 |
| $NH_4^+$ | 0.380212 | y = 0.0075x - 0.2845 |
| Ca $^{++}$ | 0.407836 | y = 5.2363x - 110.31 |
| $Mg^{++}$ | 0.423868 | y = 2.4744x - 58.749 |
| $P2O4^{++}$ | 0.48129 | y = 0.0568x - 1.8583 |
| CO2 | 0.409589 | y = 1.0493x - 8.9634 |
| $Na^+$ | 0.362445 | y = 5.1965x - 112.22 |
| $K^+$ | 0.290813 | y = 0.0743x + 0.0436 |
| Fe | 0.226278 | y = 0.0041x + 0.0627 |
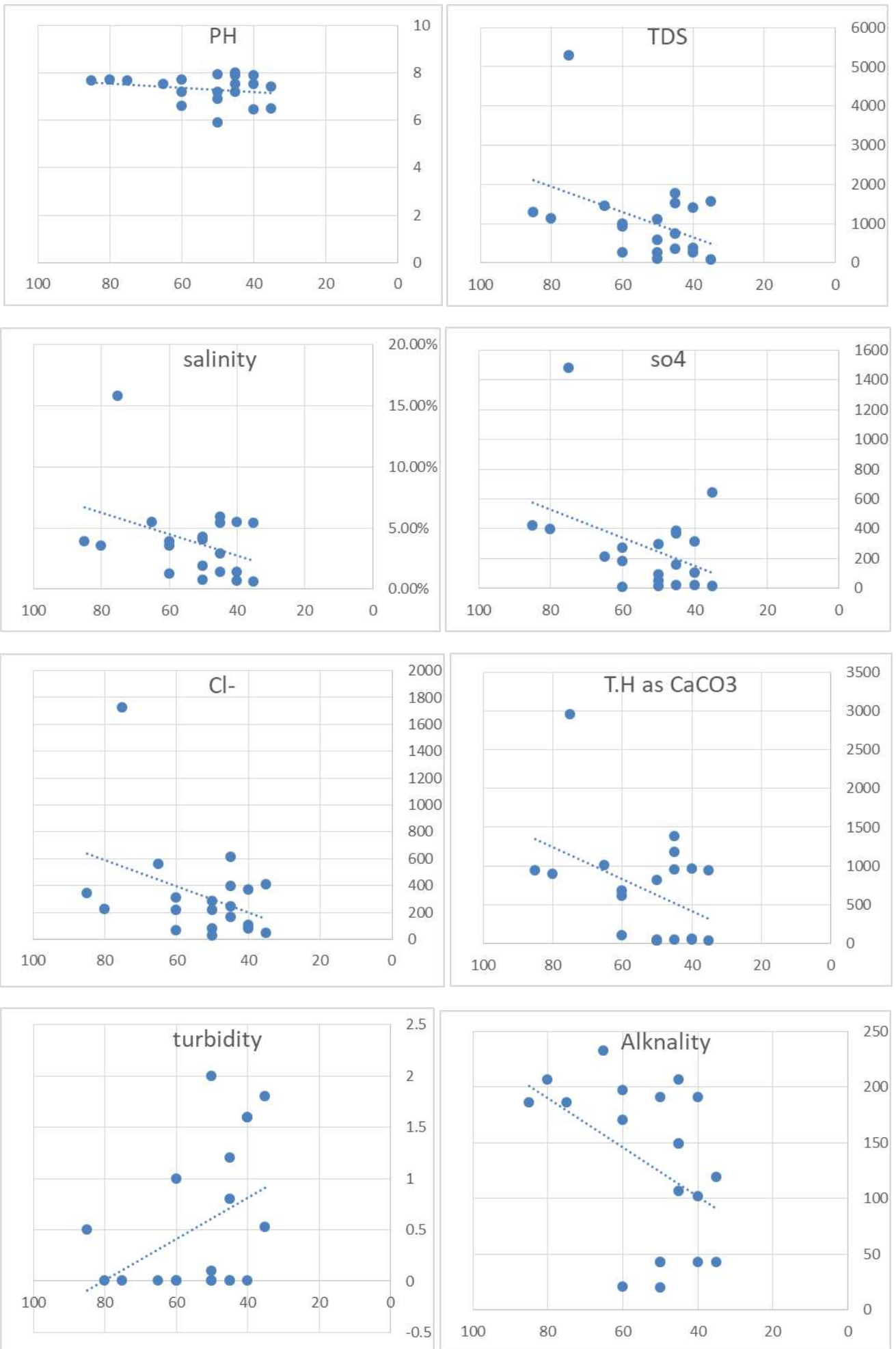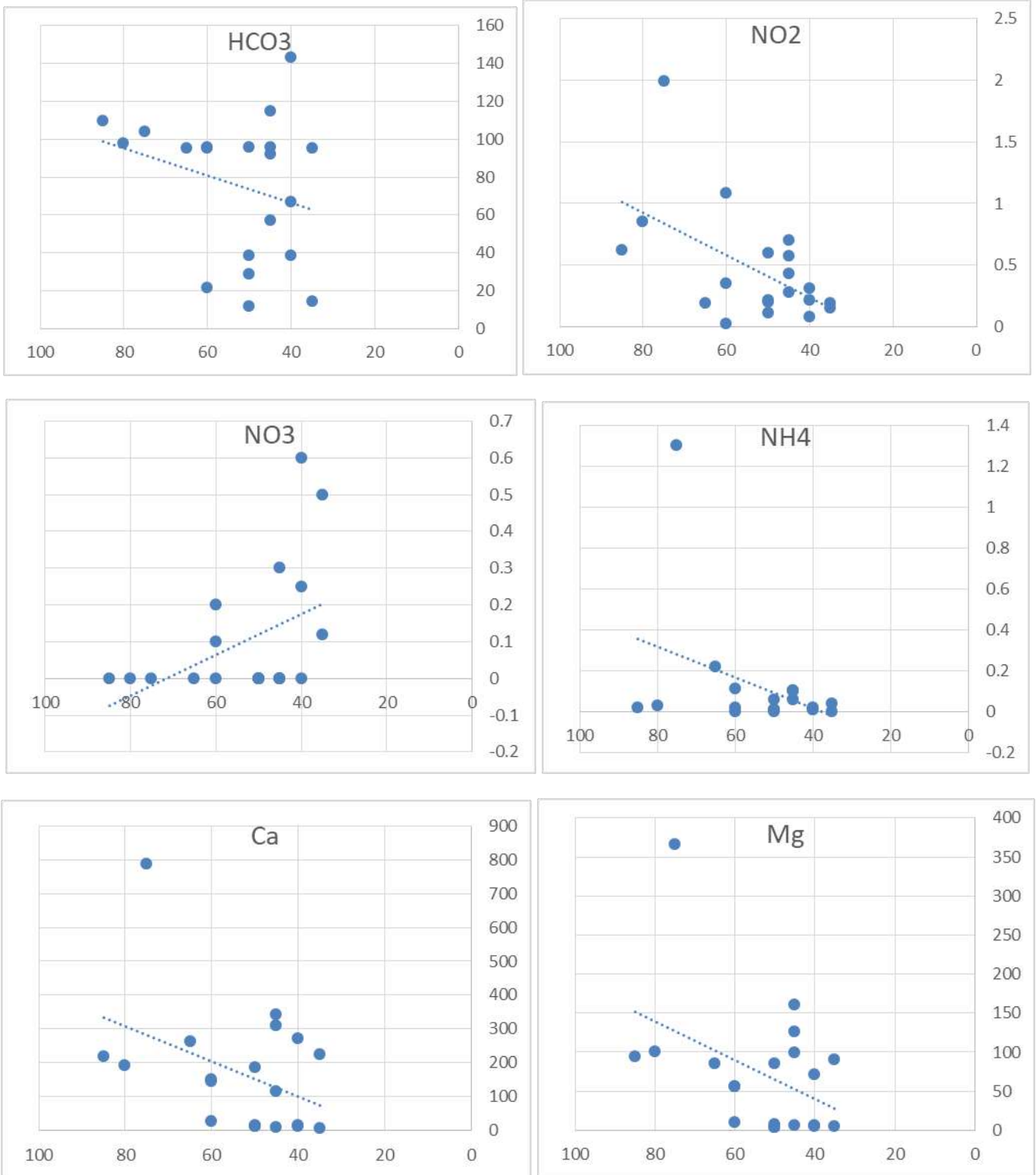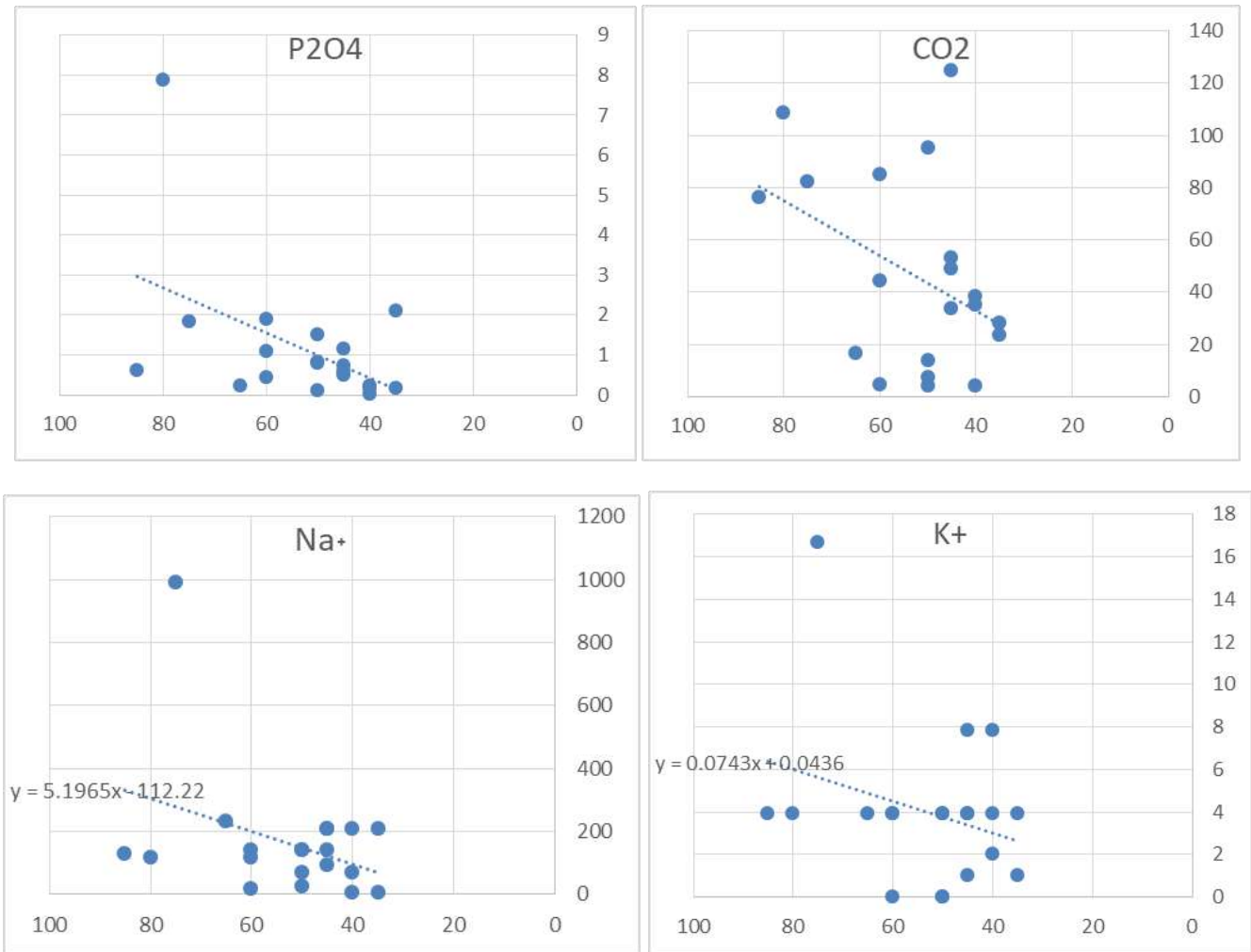
**Fig 1:** regressions for chemical components and the well depth

**Table 4:** Molar ratio values of the groundwater in 20 locations

| Sit | Depth | Na⁺/Cl⁻ | Ca²⁺ /Mg⁺² | Na⁺/K⁺ | Ca²⁺/SO4⁺² | Mg⁺²/Cl⁻ | HCO³⁻/Cl⁻ |
|---|---|---|---|---|---|---|---|
| P1 | 40 | 0.560672 | 3.828854 | 26.47059 | 0.864608 | 0.191495 | 2.582179 |
| P2 | 40 | 0.06274 | 3.280255 | 2.45 | 0.705479 | 0.060307 | 2.043433 |
| P3 | 65 | 0.410055 | 3.097877 | 58.82353 | 1.253938 | 0.151186 | 5.879455 |
| P4 | 50 | 0.485915 | 2.1875 | 35.38462 | 0.625211 | 0.298592 | 2.973822 |
| P5 | 45 | 0.38111 | 0.723471 | 23.52941 | 6.148541 | 0.663629 | 2.52669 |
| P6 | 60 | 0.52249 | 2.575221 | 29.41176 | 0.537893 | 0.256701 | 2.304712 |
| P7 | 35 | 0.137529 | 1.644681 | 5.9 | 0.515333 | 0.109557 | 2.993719 |
| P8 | 60 | 0.441741 | 2.660177 | 35.38462 | 0.840604 | 0.180858 | 3.274633 |
| P9 | 45 | 0.84507 | 1.637288 | 138 | 0.060375 | 0.03613 | 2.849913 |
| P10 | 45 | 0.520624 | 3.131446 | 26.47059 | 0.840434 | 0.248742 | 3.469459 |
| P11 | 50 | 0.626988 | 2.795181 | 0.00 | 0.130926 | 0.018855 | 5.758765 |
| P12 | 50 | 0.883483 | 4.325843 | 0.00 | 0.30315 | 0.045583 | 2.721254 |
| P13 | 40 | 0.647887 | 2.192982 | 17.69231 | 0.124254 | 0.053521 | 1.594311 |
| P14 | 50 | 0.855019 | 1.723188 | 5.882353 | 0.891973 | 0.256506 | 2.355517 |
| P15 | 35 | 0.51149 | 2.501665 | 52.94118 | 0.35109 | 0.222634 | 4.242138 |
| P16 | 45 | 0.339289 | 2.710214 | 52.94118 | 0.892103 | 0.207015 | 6.617137 |
| P17 | 85 | 0.370533 | 2.31679 | 32.35294 | 0.52488 | 0.277387 | 3.117808 |
| P18 | 80 | 0.510657 | 1.921 | 29.41176 | 0.486329 | 0.44405 | 2.297959 |
| P19 | 75 | 0.574652 | 2.1533 | 59.39676 | 0.532836 | 0.212515 | 16.5896 |
| P20 | 60 | 0.275229 | 2.504762 | 0.00 | 3.867647 | 0.16055 | 3.020785 |
| Upper limit | | 0.88348 | 4.32584 | 138 | 6.14854 | 0.66363 | 16.5896 |
| Lower limit | | 0.06274 | 0.72347 | 0 | 0.06038 | 0.01886 | 1.59431 |
| Mean ±SD | 52.75 ± 14.46184 | 0.498159 ± 0.21546 | 2.495585 ± 0.812503 | 31.62218 ± 31.84079 | 1.02488 ± 1.443147 | 0.204791 ± 0.151537 | 3.960664 ± 3.259324 |

**Table 5:** Correlation coefficient values and regression equations for molar ratios and the well depth

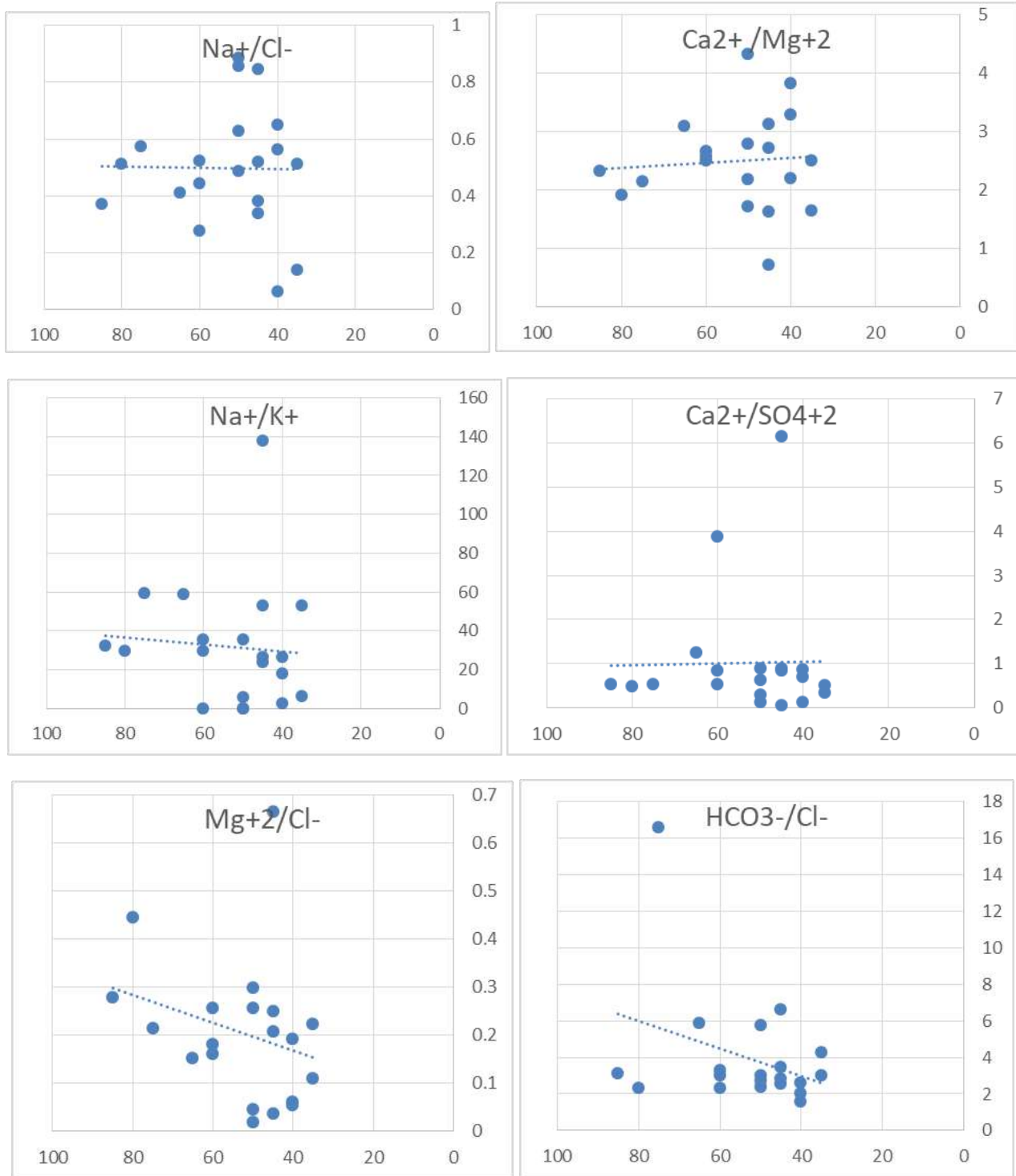| Parameters | R | Regression equations |
|---|---|---|
| $Na^+/Cl^-$ | 0.015584 | y = 0.0002x + 0.4859 |
| $Ca^{2+}/Mg^{+2}$ | -0.07644 | y = -0.0043x + 2.7221 |
| $Na^+/K^+$ | 0.084268 | y = 0.1855x + 21.835 |
| $Ca^{2+}/SO4^{+2}$ | -0.02134 | y = -0.0021x + 1.1372 |
| $Mg^{+2}/Cl^-$ | 0.276538 | y = 0.0029x + 0.0519 |
| $HCO^{3-}/Cl^-$ | 0.336213 | y = 0.0758x - 0.0364 |



**Fig 2:** Regressions for molar ratios and the well depth

Table (4) shows the Molar ratio values of the groundwater in 20 locations. Hydrogeochemical molar ratios are a useful tool to determine the origin of groundwater, and they allow understanding the reactions that occur on its way from the recharge zones to the discharge points. They have a direct relationship with the materials through which water circulates and with the phenomena that change its composition (Mahmoudi *et al,* 2017) [16].

In present study, different ionic relationships were evaluated to understand the groundwater chemistry in Sabratha region.

The value of the Na+/Cl- molar ratio was studied. If the halite solution is responsible for the presence of Na+, this molar ratio is approximately 1 (Chang and Wang, 2010) [4]. On the other hand, if the value of this ratio is >1, it can be assumed that Na+ is released from a weathering reaction or any other reason (Berhe *et al,* 2017) [3], with an ion-exchange process (Redwan and, Moneim 2016) [21]. In the current studied area, the Na+/Cl- molar ratio varied from 0.88348 and, 0.06274, with an average of 0.498159 ± 0.21546, which means that all samples show Na+ release as a result of a silicate weathering reaction process, as demonstrated by hydrochemical facies.

When the values of the Ca2+/Mg2+ ratio are close to 1.0, they indicate groundwater controlled by the dolomite solution, while values between 1.0 and 2.0 show the dissolution of the calcite. In natural waters where this proportion is greater than 2, the dissolution of silicate minerals that contribute to the enrichment of Ca2+ and Mg2+ in groundwater can be assumed (Sheikh, *et al*, 2017) [24] In this study, relationships between Ca2+ and Mg2+ molar ratio ranged between 4.325 and 0.723 were observed, with an average recorded 2.4955 ± 0.8125, indicating a process of dissolution of the silicate minerals, providing Ca2+ and Mg2+ from the rock to the groundwater. On the other hand, when the values of the Na+/K+ ratio are close to 1.0, they indicate groundwater controlled by the dolomite solution, while values between 1 and 2 show the dissolution of the calcite. In the present study, relationships between Na+/K+ molar ratio ranged between 138 and 0.0 with an average recorded 31.622 ± 31.840. a great variation of Na+/K+ molar ratio was recorded clearing that, a great amounts of Na+ and K+ ions are released in the ground water in the area of the study.

Values of the Ca2+/SO42- ratio indicate the elimination of calcium, either by precipitation as calcium carbonate, by ion-exchange processes, or both. These two processes are more abundant in shallow groundwater than in deep groundwater. Water with high Ca2+/SO42- ratios indicates the addition of calcium from the weathering of minerals rich in this element, other than gypsum (Salem and, Osman 2017) [23] In the studied area, values of this relationship between 6.148 and 0.060 were obtained, with an average of 1.024 ± 1.443, showing a low weathering of Ca2+ processes from the aquifer rock.

The effect of the water–rock interaction predominates if the Mg2+/Cl- ratio is higher than 1.0, which indicates a more significant contribution of magnesium to the water as a result of the dissolution of magnesium silicates (Custodio *et al,* 1996) [6] In the studied area, this proportion was observed between 0.663 and 0.0188, with an average of 0.2047 ± 0.1515. The interaction between water and rock prevail in most sites with a contribution of Mg2+ as a result of the dissolution of magnesium silicates. The ratio was less than 1.0 in all studied wells, showing a greater depth of the water.

Values greater than 1.0 of HCO3-/Cl- ratio are frequently observed in cold groundwater, with a short flow path and rapid circulation. Values under 1.0 indicate the presence of thermal water, with greater subsurface flow path and deep circulation (Cuoco *et al,* 2010) [5] In the studied area, HCO3-/Cl- ratio ranged between 16.589 and 1.594 was obtained with an average of 3.960 ± 3.259., indicating the presence of cold water of short and rapid path through the aquifer.

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