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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 %, SO_4^{--} , Cl, T.H (CaCO₃), Ca. as CaCO₃, Mg, CaCO₃, Alkalinity, HCO_3^- , NO_2^- , NO_3^- , NH_4^+ , Ca^{++} , Mg^{++} , PO_4^{++} , 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, HCO_3^- , NO_3^- , NH_4^+ , 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^- , $\text{Ca}^{2+}/\text{Mg}^{2+}$, Na^+/K^+ , $\text{Ca}^{2+}/\text{SO}_4^{2-}$, $\text{Mg}^{2+}/\text{Cl}^-$ and $\text{HCO}_3^-/\text{Cl}^-$) 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: HCO_3^- , NO_3^- , NH_4^+ , 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 $\text{Ca}^{2+}/\text{SO}_4^{2-}$ (1.02488 ± 1.443147). all estimated molar ratios recorded a positive correlation coefficient values with the well depth except $\text{Ca}^{2+}/\text{Mg}^{2+}$ and $\text{Ca}^{2+}/\text{SO}_4^{2-}$ 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 approximately 14 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 poisoning. 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

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 bioaccumulate 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 HNO₃ 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 %, SO₄⁻, Cl⁻, T.H (CaCO₃), Ca, as CaCO₃, Mg, CaCO₃, Alkalinity, HCO₃⁻, NO₂⁻, NO₃⁻, NH₄⁺, Ca⁺⁺, Mg⁺⁺, PO₄⁺⁺, 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
HCO ₃	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
P ₂ O ₄ ⁺⁺	0.027	7.88	1.13935	1.707537
CO ₂	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

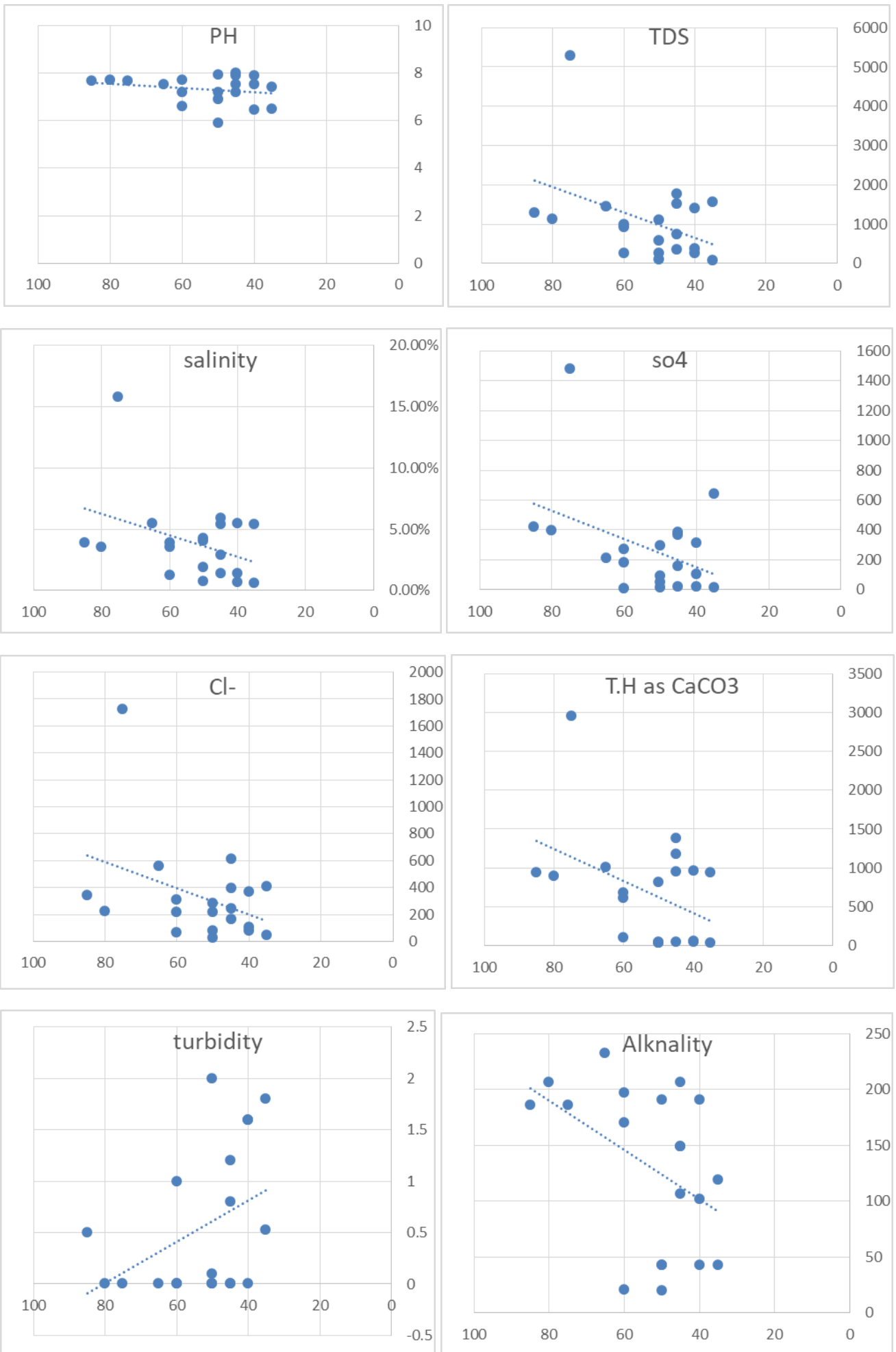
Water quality parameter	(WHO)	PI Index	Classification
pH	6.5-8	1.008897	unacceptable
TDS	1000	1.067015	unacceptable
SO ₄ ⁻	250	1.08611	unacceptable
Cl ⁻	250	1.29406	unacceptable
T.H (CaCO ₃)	100	6.874435	unacceptable
HCO ₃	300	0.251743	acceptable
NO ₃	45	0.0023	acceptable
NH ₄ ⁺	1.5	0.074	acceptable
Ca ⁺⁺	200	0.829508	acceptable
Mg ⁺⁺	150	0.478523	acceptable
P ₂ O ₄ ⁺⁺	0.13	8.764231	unacceptable
Na ⁺	200	0.809463	unacceptable
K ⁺	30	0.132133	unacceptable
Fe	1.5	0.187333	unacceptable

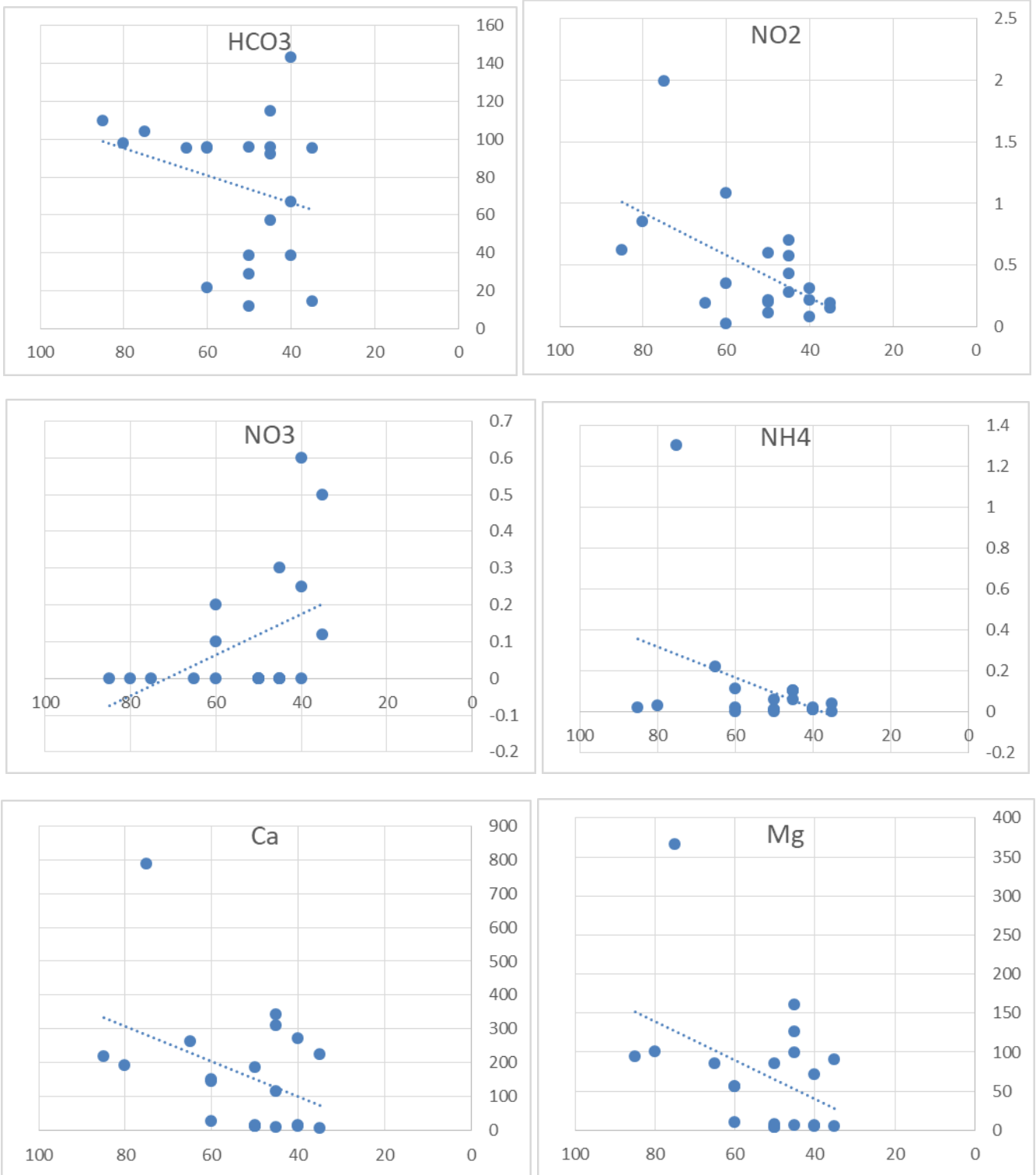
As shown in fig (1) a positive correlation values were recorded between the depth of the well and all the parameters of the study except salinity. A possible explanation is that a great amount of salts are abundant deeply in the ground and dissolved in the ground water. On the other hand, TDS, SO₄⁻, TH (CaCO₃), Ca⁺⁺, Cl⁻ and Mg⁺⁺ were higher than the standard levels recognized by (WHO2004) and (ISI 1995). A great variation between investigated values and standard ones are occurred in an important chemical components such as TDS, Mg⁺⁺ and TH (CaCO₃) 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
HCO ₃	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
P ₂ O ₄ ⁺⁺	0.48129	y = 0.0568x - 1.8583
CO ₂	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





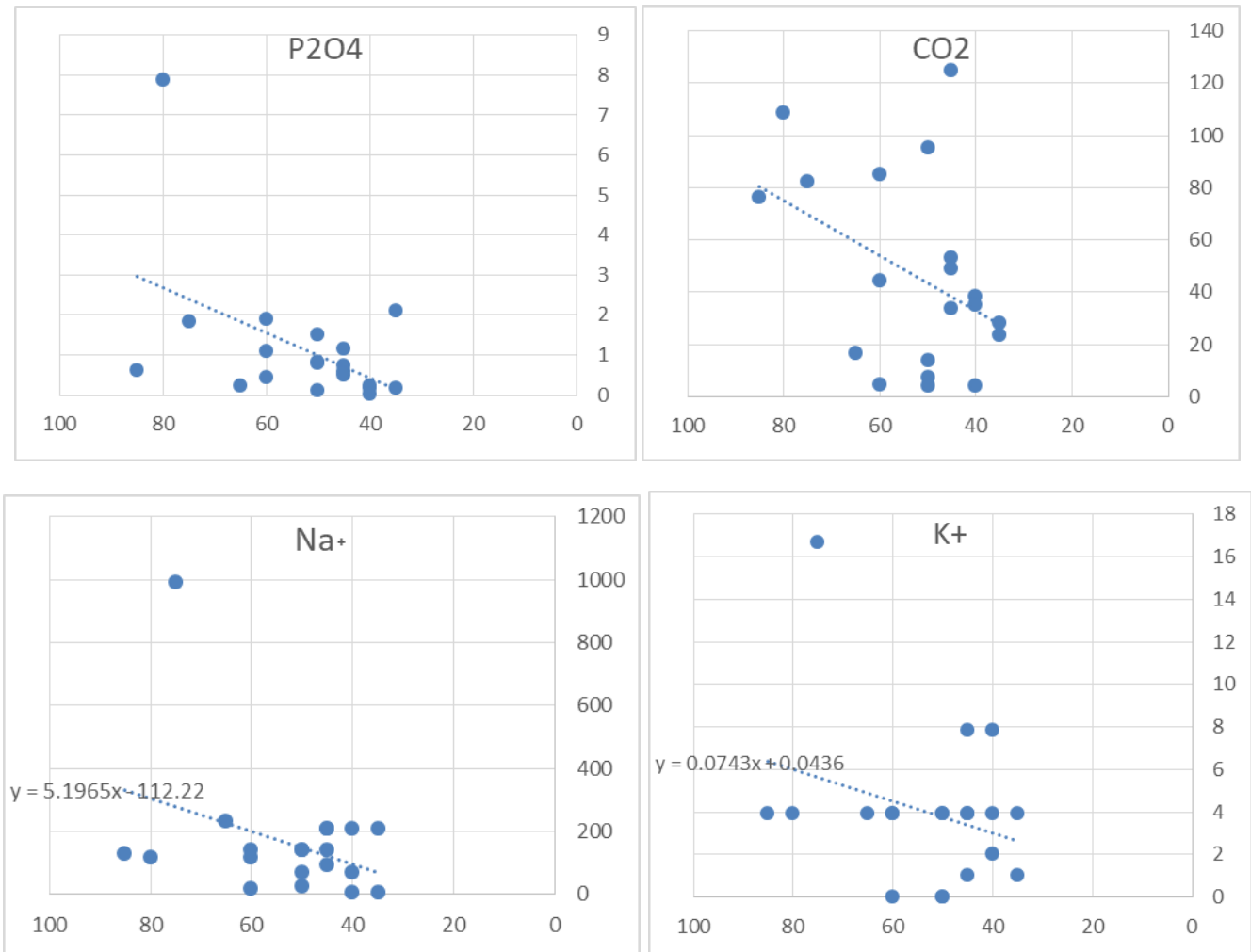


Fig 1: regressions for chemical components and the well depth

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

Sit	Depth	Na ⁺ /Cl ⁻	Ca ²⁺ /Mg ⁺²	Na ⁺ /K ⁺	Ca ²⁺ /SO4 ⁺²	Mg ⁺² /Cl ⁻	HCO ³⁻ /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	52.75 ±	0.498159 ±	2.495585 ±	31.62218 ±	1.02488 ±	0.204791 ±	3.960664 ±
±SD	14.46184	0.21546	0.812503	31.84079	1.443147	0.151537	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⁺ /SO ₄ ⁺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

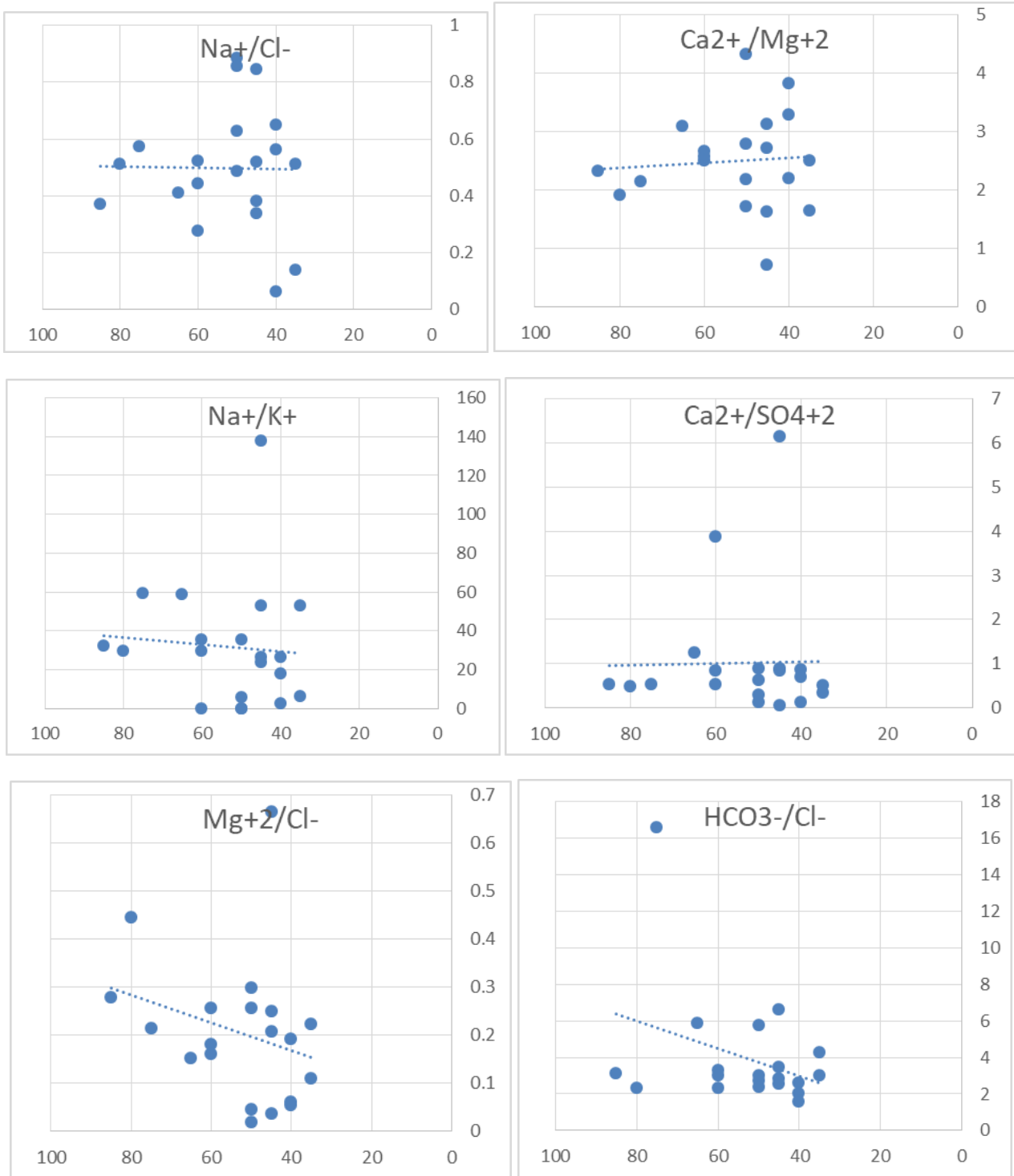


Fig 2: Regressions for molar ratios and the well depth

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.

References

1. Akpoveta OV, Okoh BE, Osakwe SA. Quality assessment of borehole water used in the vicinities of Benin, Edo State and Agbor, Delta State of Nigeria. *Current Research in Chemistry* 2011;3:62-69.
2. Appelo CAJ, Postma D. *Geochemistry. Groundwater and Pollution*. Balkema, Rotterdam, the Netherlands 1993.
3. Berhe BA, Dokuz UE, Çelik M. Assessment of hydrogeochemistry and environmental isotopes of surface and groundwaters in the Kütahya Plain, Turkey. *J. Afr. Earth Sci* 2017;134:230–240
4. Chang J, Wang G. Major ions chemistry of groundwater in the arid region of Zhangye Basin, northwestern China. *Environ. Earth Sci* 2010;61:539–547.
5. Cuoco E, Verrengia G, De Francesco S, Tedesco D. Hydrogeochemistry of Roccamonfina volcano (southern Italy). *Environ. Earth Sci* 2010;61:525–538.
6. Custodio E, Llamas M. *Hidrología Subterránea Volume 2*, 1st ed.; Barcelona, O., Ed.; Omega: Barcelona, Spain 1996.
7. Ergul HA, Varol T, Ay U. Investigation of heavy metal pollutants at various depths in the Gulf of Izmit. *Marine Pollution Bulletin* 2013;73:389–393.
8. Esteller MV, Kondratenko N, Expósito JL, Medina M, Del Campo MM. Hydrogeochemical characteristics of a volcanic-sedimentary aquifer with special emphasis on Fe and Mn content: A case study in Mexico. *J. Geochem. Explor* 2017;180:113-126.
9. Gopinath M. Groundwater quality assessment in Pungar sub basin, Tamilnadu, India, Unpublished M.Phil., Thesis, Annamalai University 2011.
10. Hem JD. Study and interpretation of the chemical characteristics of natural waters. United States Geological Survey, Water Supply Paper 1473. USGS, Washington, D.C 1985.
11. Hem JD. Study and interpretation of the chemical characteristics of natural waters. Book 2254, third edition. Scientific Publishers, Jodhpur 1991.
12. Ikejimba CC, Sakpa S. Comparative study of some heavy metals' concentrations in water and *Tympanotonus fuscatus* var *radula* samples of Egbokodo River, Warri, Nigeria. *International journal of Modern Biological Research* 2014;2:7-15.
13. Javid Hussain, Farman Ullah Khan, Riaz Ullah Zia Muhammad, Najeeb U Rehman, Zabta Khan Shinwari, Ihsan Ullah Khan *et al.* Nutrient Evaluation And Elemental Analysis Of Four Selected Medicinal Plants Of Khyber Pakhtoon Khwa, Pakistan. *Pak. J. Bot* 2011;43(1):427-434.
14. Karanth KR. *Groundwater Assessment, Development and Management*. Tata McGraw – Hill Publishers, New Delhi 1997.
15. Khan MQMA, Umar R, Latch H. Study of trace elements in groundwater of Uttar Pradesh, India. *Sci. Res. Essays* 2010;5(20):3175-3182.
16. Mahmoudi N, Nakhaei M, Porhemmat J. Assessment of hydrogeochemistry and contamination of Varamin deep aquifer, Tehran Province, Iran. *Environ. Earth Sci* 2017;76:370.
17. Mohammad Muqtada Ali Khan *et al.* Study of trace elements in groundwater of Western Uttar Pradesh, India 2005.

18. Nash H, McCall GJH. Ground water quality (Eds.). 17th Special Report. Chapman and Hall, London 1995.
19. Njitchoua R, Dever L, Fontes JCH, Naah E. Geochemistry, origin and recharge mechanisms of groundwater from the Garoua Sandstone aquifer, northern Cameroon. *Journal of Hydrology* 1997;190:123–140.
20. Rao KN, Latha PS. Groundwater quality assessment using water quality index with a special focus on vulnerable tribal region of Eastern Ghats hard rock terrain, Southern India. *Arab. J. Geo Sci* 2019;12:1-16.
21. Redwan M, Moneim AAA. Factors controlling groundwater hydrogeochemistry in the area west of Tahta, Sohag, Upper Egypt. *J. Afr. Earth Sci* 2016;118:328–338
22. Sahoo MM, Swain JB. Modified heavy metal Pollution index (m-HPI) for surface water Quality in river basins, India. *Environ. Sci. Pollut. Res* 2020.
23. Salem ZES, Osman OM. Use of major ions to evaluate the hydrogeochemistry of groundwater influenced by reclamation and seawater intrusion, West Nile Delta, Egypt. *Environ. Sci. Pollut. Res* 2017;24:3675-3704.
24. Sheikh MA, Azad C, Mukherjee S, Rina K. An assessment of groundwater salinization in Haryana state in India using hydrochemical tools in association with GIS. *Environ. Earth Sci* 2017;76:465.
25. Subramani T, Elango L, Damodarasamy SR. Groundwater quality and its suitability for drinking and agricultural use in Chithar River Basin, Tamil Nadu, India. *Environmental Geology* 2005;47:1099-1110.
26. Tiwari RN, Dubey DP. A study of Bauxite deposit of Tikar Plateau Rewa district, M.P. *Gond. Geol. Soc. Sp* 2012;13:111-118,
27. WHO/UNICEF. Estimated data from WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation. Progress 2012.