APPLICATION NOTE

Marine aquariums

How to control water parameters in marine aquariums using Exaqua photometer

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INTRODUCTION

Marine aquaristics has been widely available for nearly 30 years, gaining a growing community of enthusiasts every day. The level of knowledge among aquarists, the multitude of information materials on forums, blogs, and in specialized publications, as well as a wide selection in the market of aquarium equipment, specimens of fauna and flora, and measurement devices, causes that creating a coral reef at home with a variety of corals, sponges, crustaceans and fish is within the reach of an ever-increasing number of enthusiasts.

However, seawater is a complex and delicate ecosystem that reveals its beauty only to those who take proper care of it. A fundamental prerequisite is to take care of water quality. Monitoring essential water parameters, and therefore taking regular at least weekly measurements, should remain a habit of every marine aquarist. Abandoning the measurement routine and relying on so-called "good" results obtained once over a long time period may lead to a sudden collapse of the biochemical balance in the tank, often resulting in the death of corals, which are expensive to buy and difficult to keep, and in the fish moving, as some aquarists humorously put it, to ‘the eternal reef’.

Ideal parameters of seawater in an aquarium are also highly dependent on the type of organisms inhabiting the tank. For example, some fish can adapt to quite high levels of nitrates and phosphates, and only a sharp jump in one of the parameters can lead to their death. However, hard corals, especially SPS (Small Polyped Stony Corals), do not tolerate practically any errors by the aquarist. In each of these cases, thorough monitoring of water parameters is the key to avoiding undesirable changes in the tank and putting in jeopardy months of effort in creating one’s own piece of coral reef.

A conscious aquarist, passionate about marine biotopes, should have an established measurement routine based on reliable tests or measuring devices. Exaqua photometers excel in this role. This application note provides information on the impact on the condition of a marine aquarium of the most important water parameters, whose convenient and reliable measurement is enabled by Exaqua photometers.

photometer reinvented

HOW TO TAKE CARE OF MARINE AQUARIUMS USING THE EXAQUA PHOTOMETER

The multiparameter Exaqua photometer is a precise measuring device which, when combined with reagent kits, enables accurate control of seawater quality. Photometric measurements have one significant advantage over traditional colorimetric tests — they free the user from subjectively assessing the coloration of the sample solution and comparing it with a color scale included with the test. It significantly increases the accuracy and repeatability of the obtained results.

Exaqua enables comprehensive monitoring of saltwater in terms of measuring:

- basic parameters such as pH, total and carbonate hardness,
- content of essential ions such as: nitrates, nitrites, phosphates, or sulphates,
- content of macroelements (e.g. calcium and magnesium, so important in the composition of seawater),
- microelements (including copper, silicon, iodine and iron).

HOW THE EXAQUA PHOTOMETER WORKS

The Exaqua photometer works by analyzing the light passing through a sample of liquid. To measure a specific parameter, a range of reagents are added to the water sample before measurement to obtain a color of the solution with an intensity depending on the concentration of the test substance. The value of absorbance measured by the photometer is used to calculate automatically the concentration of the test substance. The photometer functions correctly even with coloured samples, thanks to a reference measurement (known as a "blank test") on a sample without added reagents.

BASIC FEATURES FOR EASE OF PHOTOMETER USE

The device is equipped with a number of features that facilitate its operation and increase the quality of measurements. The most important include:

rayject technology applied in Exaqua devices, makes them the only photometers on the market that have absolute resistance to external light. Measurements can be conducted even with an uncovered vial, both outdoors in full sun and in a well-lit laboratory without fear of adverse effect on results.

The method guide is a mode that every Exaqua photometer method is equipped with. It acts as a guide that leads the user step by step through the whole procedure of a measurement, indicating in what quantity and what type of reagent should be added and counting down the reaction time whenever necessary. The prompts are displayed on the photometer screen during measurement after pressing the GUIDE button.

exatir system is an innovative system for a simple and convenient photometric titration measurement. One of the most significant function of this system is to recognize and indicate acoustically the end of the titration. In this way the user does not need to observe the color change of the sample while adding the titrant to the solution of analyte.

Exaqua REPORTER is a mobile application thanks to which Exaqua users, apart from collecting measurement results in the photometer itself, can also analyze them on a mobile device. The mobile application allows users to collect, sort and group data, create charts, and export the data in the form of spreadsheets and PDF files.

EXAQUA MARINE SET
Ready-made Exaqua test kit for measurements in marine water
Constant monitoring of seawater parameters is essential for the proper functioning of a marine aquarium.
It is better to keep it always in mind than to have the Dead Sea in your aquarium.

WHICH SEAWATER PARAMETERS CAN BE TESTED WITH THE EXAQUA PHOTOMETER

Optimal concentration ranges or levels for individual water parameters depend on the type of marine aquarium and the species of fish and corals it contains. Good aquaristic practice involves maintaining concentrations or values of individual parameters within recommended ranges. For this reason, it is advisable to carefully observe the condition of marine organisms and water quality to determine the most favourable levels depending on the specifics of the biotope created in your own marine aquarium. Below are the indicative values of optimal conditions in a marine aquarium and a list of Exaqua methods by which they can be measured.

TABLE 1

List of parameters measured by the Exaqua photometer and optimal levels of these parameters recommended to be maintained in a marine aquarium

PARAMETER	SPECIFICATION OF PARAMETERS MEASURED USING EXAQUA METHODS				
Optimal level in marine aquarium*	Method name	Method no.	Method range	Method resolution	Measurement error
pH 8 – 8.4	pH 4.5-9	Z050M	4.5 – 9.0	0.05 pH	±0.1 pH
KH 8 – 12 dKH	Alkalinity KH	Z010M	0.5 – 20 dH	0.5° dH	±5% ±0.5 °dH
NH_4 0 ppm	Total ammonia NH4	Z231	0.1 – 3 ppm	0.05 mg/l	±5% ±0.05 ppm
	Total ammonia NH4 trace level range	Z231L	25 – 300 ppb	> 100 ppb - 0,1 ppb < 100 ppb - 1 ppb	± 10% ±10 ppb
NO_2 0 ppm	Nitrite NO2 high range	Z220H	1 – 6 ppm	0.05 ppm	±5% ±0.1 ppm
	Nitrite NO2 low range	Z220L	0.02 – 1.5 ppm	0.01 ppm	±3% ±0.02 ppm
NO_3 1 – 4 ppm	Nitrate NO3 high range	Z210L	5 – 150 ppm	1 ppm	±10% ±5 ppm
	Nitrate NO3 low range	Z220H	0.5 – 30 ppm	0.5 ppm	±10% ±1 ppm
SO_4 2000 – 3000 ppm	Sulphate SO4	Z610M	200 – 3000 ppm	20 ppm	±10% ±20 ppm
PO_4 0.02 – 0.05 ppm	Phosphate PO4	Z240M	0.05 – 10 ppm	0.01 ppm	±5% ±0.05 ppm
Ca 400 – 450 ppm	Calcium Ca	Z462	200 – 600 ppm	8 ppm	±3% ±8 ppm
Mg 1200 – 1450 ppm	Magnesium Mg	Z463	500 – 1600 ppm	18 ppm	±3% ±18 ppm
I_2 60 – 100 ppb	Iodine I2	Z480M	10 – 200 ppb	5 ppb	±10% ±5 ppb
Fe 0.01 – 0.05 ppm	Iron Fe	Z420	0.05 – 10 ppm	0.01 ppm	±3% ±0.05 ppm
Cu 0 ppm	Copper Cu	Z430M	0.08 – 3 ppm	0.02 ppm	±5% ±0.02 ppm
Si 0.02 – 0.3 ppm	Silicon Si	Z440	0.05 – 7 ppm	0.01 ppm	±3% ±0.05 ppm
K 375 – 450 ppm	Potassium K	Z450M	50 – 500 ppm	2.5 ppm	±10% ±10 ppm

* All ranges are indicative. The most optimal conditions depend on the type of marine aquarium including, among others, the quantity and species of fish and corals. Their precise determination requires careful adjustment of individual parameters and close observation of the aquarium condition.

pH value is one of the essential water parameters, which determines the healthy life of fish and other aquatic organisms. The optimal pH level in a marine aquarium should be between 8.0 and 8.4. Too low pH can adversely affect the health of fish and corals, while too high pH, in addition to harming organisms, can lead to calcium deposition on the surfaces of heating elements or pumps. In the case of pH, stability is just as important as maintaining its specific level. Large pH fluctuations can lead to health problems for fish and corals. For this reason, pH levels should not be corrected too rapidly by adding too much supplements. In an aquarium, pH is strongly related to alkalinity— higher KH levels slow down pH changes.

For photometric pH measurements, Exaqua offers the **Z050M** method - a wide-range colorimetric method tailored to the marine matrix, spanning the range of normal pH values along with pathological peripheries. The method provides results in the pH range of 4.5-9.0 with a resolution of 0.05 pH.

Alkalinity/Carbonate Hardness (KH) is a measure of the concentration of bicarbonates in water. It determines the acid capacity of water and its ability to stabilize pH. It affects many processes in a marine aquarium, such as metabolism and coral growth. Alkalinity directly represents the concentration of bicarbonates - compounds that constitute the building material for coral skeletons. The optimal alkalinity level in a marine aquarium is between 8 and 12 dKH. Values below 7 dKH or above 15 dKH are considered as unfavorable. In natural seawaters, alkalinity generally remains at the level of 7 dKH.

The **Z010M** method allows for KH measurements in seawater in the range of 0.5 - 20 °dH with a resolution of 0.5 °dH.

Ammonium compounds, which consist of ammonium ions (NH_4^+) and ammonia (NH_3), are one of the indicators of biological water contamination. They are formed as a result of decomposition of organic nitrogen, e.g. during decomposition of food or as a result of fish metabolism. With an increase in pH, the percentage content of ammonia (NH_3) relative to ammonium ions (NH_4^+) increases. Thus, in marine aquariums where pH of water usually remains above 8, there is a significant predominance of ammonia over ammonium ions. Although the presence of ammonia is a natural phenomenon, it is a compound toxic to fish, and its level should be kept as close to 0 ppm as possible. Aquarists usually remember to control the content of ammonia when setting up a new tank, and thus monitor the ongoing nitrogen cycle in a maturing new aquarium. Ammonia is converted into nitrites and then into nitrates as a result of the activity of beneficial bacterial microflora and the absorption of these compounds by plants. However, as it is often the case with mature, stabilized aquariums, further measurements of ammonia content should not be neglected, because, due to the decomposition of plant fragments, dead animals, or uneaten food, the content of this compound can suddenly increase to a level toxic to the tank's inhabitants.

Exaqua offers the **Z231** method for monitoring the total ammonia content in seawater, with a range of 0.1 - 3 ppm and a resolution of 0.05 ppm. For advanced users, the **Z231L** method is also available for determining total ammonia at the trace level with a range of 25 – 300 ppb. Method Z231L uses the Z231 reagent set and an alternative procedure. The user method along with appropriate instructions are available for downloading in the form of an application note from the website: exaqua.com/exaqua-knowledge-center/ titled "Determination of total ammonia in ultra low range in marine water".

Nitrites and **nitrates**

Nitrites are an intermediate product of the nitrification process and, like ammonia, are toxic, especially to invertebrates. Their level in a functioning tank should be as close to 0 ppm as possible.

Nitrates are the final product of the nitrification process; in the presence of invertebrates their optimal level should be kept below 10 ppm. For many species of fish, nitrates are relatively harmless, and their level may in such cases exceed even 25 ppm. Excessively high nitrate levels above 40 ppm contribute to massive growth of algae and dinoflagellate. Too low nitrate levels often occur in aquariums with a large amount of corals, often living in symbiosis with zooxanthellae algae. Zooxanthellae absorb nitrates and simultaneously carry out photosynthesis - the process of converting solar energy into sugars, fats, amino acids, and oxygen, which corals also benefit from. Considering all these dependencies, it is advisable to maintain the optimal nitrate level in marine aquariums typically between 1 and 4 ppm.

For nitrite content measurement, Exaqua offers two universal methods: **Z220L** low range (0.02 - 1.5 ppm, resolution 0.01 ppm) and **Z220H** high range (1 - 6 ppm, resolution 0.05 ppm). Nitrate measurement is possible using methods: **Z210L** low range (0.5 - 30 ppm, resolution 0.5 ppm) and **Z210H** high range (5 -150 ppm, resolution 1 ppm).

Phosphates are chemical compounds that can lead to excessive growth of harmful algae in a marine aquarium, inhibit the development of invertebrates, and impair the calcification process of some corals and coralline algae. The acceptable level of phosphates in aquariums with invertebrates is no more than 0.05 ppm. However, its complete absence is also unfavourable. It is important to remember that phosphorus is a part of nucleic acids, phospholipids, and the main energy carrier in cells

(ATP – adenosine triphosphate), without which the functionning of many organisms' cells would not be possible. It is also needed for photosynthesis by symbiotic algae of corals. Water completely depleted of phosphate may be the cause of improper coloring of corals and their bleaching. Generally, the source of phosphate in a marine aquarium is uneaten food, fish waste, or decomposing dead animals. Phosphates are mainly removed from the aquarium using protein skimmers. Generally, the level of phosphates in a marine aquarium should be kept in the range of 0.02 to 0.05 ppm. The optimal phosphate content within the specified range should be determined by each aquarist based on their own observations of the tank, as this value may vary depending on, among other, the quantity and type of corals, the number of fish, the type of filtration, and the maturity of the tank.

The Exaqua **Z240M** method allows for the measurement of phosphates in the range of 0.05 - 10 ppm with a resolution of 0.01 ppm.

Calcium and **magnesium** are extremely important elements determining proper development of many marine organisms, therefore, monitoring their content and controlling the proper ratio of calcium to magnesium is particularly important. Calcium is the basic building block for skeletons of many marine invertebrates such as corals, clams, and many others. The optimal level of calcium is 400 - 450 ppm, but in reef aquariums, this element is constantly consumed by living organisms, which may result in a drop in its content below the acceptable level. Meanwhile, the proper level of magnesium content (between 1200 and 1450 ppm) is important for numerous biochemical processes occurring in the cells of marine organisms. The ratio of calcium to magnesium also affects the ability of invertebrates, mainly corals, to intake calcium. Ornamental red calcareous algae are particularly sensitive to magnesium deficiencies and their deteriorating condition, loss of colors, and growth inhibition are visible signals of deficiency of this element. Additionally, magnesium stabilizes the level of alkalinity. Biological and chemical processes cause constant depletion of magnesium, creating a need for its control and appropriate supplementation.

For measurements of calcium and magnesium content in seawater using Exaqua photometers, titration methods Z462 and Z463 equipped with Exatitr system. Method **Z462** allows for measurements of calcium in the range of 200 - 600 ppm with a resolution of 8 ppm, while method **Z463** is used to measure magnesium content at levels in the range of 500 - 1600 ppm with a resolution of 18 ppm.

Iodine, occurring in seawater mainly in the form of iodides and iodates (in a ratio of 1:1), is essential for the proper functioning of fish and corals. Corals and crustaceans such as shrimp and crabs need iodine to regulate metabolism and hormone production. Moreover, iodine plays a key role in the synthesis of pigments that allow corals to adapt to varying lighting conditions and protect their tissues from UV light. The optimal iodine level in a reef aquarium is considered to be between 60 and 100 ppb (0.06 – 0.10 ppm). The typical concentration of iodine in seawater is about 60 ppb. Iodine deficiency can inhibit important biological processes, and its excess is toxic to fish and invertebrates. For this reason, the iodine level in seawater must be effectively controlled, and measurements should be quite often performed due to the phenomenon of rapid disappearance of this element in the aquarium.

Method **Z480M**, designed for measuring iodine in seawater using the Exaqua photometer, allows for measurements in the range of 10 – 200 ppb with a resolution of 5 ppb.

Iron is one of the key microelements in seawater, absorbed, among others, by corals and anemones. It plays an important role in metabolic processes such as photosynthesis, respiration, and enzymatic processes. Proper supplementation of this element contributes to green coloration of corals (especially SPS and LPS). In a marine aquarium, the optimal iron level is between 0.01 and 0.05 ppm. Iron levels that are too high can lead to formation of sediment and contaminants, as well as excessive algae growth, while too low iron levels can adversely affect the development of marine organisms.

Method **Z410** allows for the measurement of iron levels in the range of 0.05 to 10 ppm with a resolution of 0.01 ppm.

Copper is one of the microelements present in seawater. It plays a role in metabolic processes and enzymatic processes in fish and other marine organisms. The optimal level of copper in marine aquariums, especially in the presence of invertebrates, should be close to 0. The amount of copper necessary for the proper course of enzymatic processes of many organisms is so small that it is not detectable by traditionally applied tests and sometimes requires the use of more advanced techniques such as ICP-OES analysis. Nevertheless, the content of copper requires constant monitoring in the aquarium because too high level of this element in the water can lead to the death of fish, bleaching and dulling of coral tissue, zooxanthellae atrophy, and the death of mollusks (clams, snails, and shrimp). It is worth noting that some fish food contain copper sulfate as a preservative, which can contribute to an increase in the copper content in the water.

Additionally, copper cations are applied for another purposes in marine aquaristics, as they are an essential ingredient of many aquarium products against protozoa, algae and fungi. The concentration of copper ions in long-term baths against protozoa should be at least 0.2 mg/l. The actual concentration of copper ions in aquarium water depends not only on the amount of added supplements, but also, to a significant extent on the composition of water and the type of aquarium substrate. In hard water, especially in seawater, some copper ions precipitate in the form of insoluble compounds, thereby reducing the effect of supplementation. For this reason, fish treatment in a quarantine tank with agents based on copper compounds requires day-to-day control of copper ion content as well supplementation of this element to the desired level to maintain its therapeutic concentration.

The **Z430M** method is designed for measuring the copper level using Exaqua photometers in the range of 0.08 - 3 ppm and with a resolution of 0.02 ppm.

Silicon is most commonly found in the form of silicates. It is an important component of seawater, necessary for the development of corals, sponges, algae, and other marine organisms. The optimal level of silicon in marine aquariums is between 0.02 and 0.3 ppm. Too low silicon level can negatively affect the growth of corals and some species of algae, while too high level can lead to excessive development of diatoms.

The level of silicon in seawater can be determined using the Exaqua photometer by utilizing method **Z440**. It allows for measurements in the range of 0.05 - 7 ppm with a resolution of 0.01 ppm.

Sulphates are essential for the proper functioning of marine organisms such as algae, corals, and marine plants. Sulphur is a part of amino acids and cofactors necessary for the proper course of enzymatic reactions. It plays an important role in building skeletons of corals. The optimal level of sulphates in a marine aquarium is between 2000 and 3000 ppm. Too low sulphate level can adversely affect the development of marine organisms, causing metabolic disorders, while too high level can lead to disruptions in development of certain plants and formation of deposits and contaminants.

Exaqua **Z610M** method is intended for measuring the sulphate content in the range of 200 - 3000 ppm and with a resolution of 20 ppm.

Potassium is an important component of seawater, necessary for the proper functioning of marine organisms such as corals and fish. It plays an essential role in the calcification process of corals and thereby building their skeletons, their proper coloring, and also participates in the transport of nutrients and the feeding of zooxanthellae (algae living in symbiosis with corals). The optimal level of potassium in marine aquariums is between 375 and 450 ppm. Too low potassium level results in metabolic disorders of marine organisms, for example: inhibition of coral growth and their fading, while too high level has toxic effects on fish, can lead to damage and death of shrimp, and contributes to the formation of spots on corals.

The Exaqua **Z450M** method is designed for measuring potassium content, in the range of 50 - 500 ppm and a resolution of 2,5 ppm.

COMPARISON OF WATER PARAMETERS FROM DIFFERENT NATURAL SEA BASINS

Marine aquaristics is a beautiful hobby that brings a lot of satisfaction and interesting experiences in recreating the natural environment of seas and oceans in the comfort of one's own home, but not only. Reef aquariums, although requiring a lot of knowledge and experience, often intolerant to the slightest mistakes by the aquarist and sensitive to equipment failure, are becoming an increasingly common element of decor in homes, hotels, schools, and other public places. However, the complex ecosystem requires precise adjustment of parameters in order to maintain a delicate balance of relationships between water parameters and the requirements of marine organisms inhabiting the aquarium. Hence, enthusiasts of reef aquariums often seek guidelines in this regard. And what else could be a better benchmark, a point of reference, than seawater from a natural waterbody? Problem is, there is no single standard seawater. The salinity and composition of waters in seas and oceans vary depending on the location from which we take a sample. This is influenced by precipitation occurring in a given region of the world, evaporation, the type of rocks being washed, the composition of the seabed, and sea currents. Nevertheless, certain consistent relationships for individual water parameters can be observed, regardless of the place from which the water sample originates.

Attached to this application note you will find a reference summary of some measurement results for a number of water parameters based on samples collected from many natural marine bodies in various parts of the world. The originator of the initiative is Sławomir Drobnik, a long-standing member of the Lodz Association of Aquarium and Terrarium keepers. Samples were collected by a group of aquarists on international beaches along oceans and seas. The analysis of the samples was conducted in a professional, state-of-the-art laboratory of the Zoolek company as part of the Aquatest express service using advanced analytical techniques such as ICP-OES and ICP-MS. This allowed for obtaining a comprehensive picture of the composition for a single water sample, even for parameters that are not detectable using methods traditionally applied by aquarists, e.g. using droplet tests.

The table was created in order to refer to information about the natural composition of water, thus regulating the parameters in one's own aquarium and striving to create conditions similar to those in real saltwater biotopes existing on our planet. And this is a good start to achieve balance in this very complicated ecosystem, especially if it is created artificially as a copy of a real body of water.

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TABLE 2 Summary of measurement results for water parameters from different natural marine bodies

Aquatest express
LABORATORY ANALYSIS OF WATER IN FRESHWATER AND MARINE AQUARIUMS
www.aquatestexpress.pl

PARAMETER		POLAND Bay of Gdansk Baltic Sea 2022	CROATIA Makarska Adriatic Sea 2022	EGYPT Marsa Alam Red Sea 2022	EGYPT Marsa Alam Red Sea 2023	TANZANIA Zanzibar Pacific Ocean 2022	INDONESIA Raja Ampat Pacific Ocean 2023	GREECE Rodos-Fairaki Mediterranean 2023	KENYA Diani Beach Indian Ocean 2024	CUBA Varadero Atlantic Ocean 2024	CUBA Varadero Atlantic Ocean 2021	PORTUGAL Portimao Atlantic Ocean 2021
		RESULTS										
Salinity	ppt	6.77	40.64	46.29	42.90	36.13	35.00	40.08	36.13	37.82	37.82	36.13
Carbonate hardness (KH)	°d	6.00	8.00	7.50	7.00	5.00	6.50	7.50	6.00	7.00	4.50	7.50
Nitrate (NO_3^-)	ppm	0.50	1.00	0.50	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.76
Nitrite (NO_2^-)	ppm	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Chloride (Cl^-)	ppm	10 840.00	23 000.00	25 540.00	-	17 276.13	-	-	-	-	-	-
Phosphate (PO_4^{3-})	ppm	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00
Ammonia (NH_4^+)	ppm	0.70	0.00	0.00	0.00	0.00	0.10	0.00	0.30	0.00	0.00	0.00
Sodium (Na)	ppm	3 248.00	12 310.00	12 960.00	-	8 471.91	9 763.24	-	10 083.43	10 509.90	-	11 564.45
Calcium (Ca)	ppm	81.59	343.20	407.80	-	449.92	423.70	-	456.23	425.97	443.32	491.66
Magnesium (Mg)	ppm	285.30	1 453.00	1 649.00	-	1 390.05	1 364.24	-	1 408.94	1 402.18	1 416.62	1 361.28
Potassium (K)	ppm	71.44	485.70	499.30	-	401.15	401.30	-	405.82	412.17	439.13	412.97
Bromine (Br)	ppm	11.73	55.10	64.01	77.41	45.49	64.33	73.00	65.05	65.62	53.95	56.63
Boron (B)	ppm	0.64	3.84	4.06	4.96	4.26	3.97	4.72	4.24	5.07	4.24	3.62
Strontium (Sr)	ppm	1.62	7.46	8.31	-	6.79	-	-	-	-	-	-
Sulphur (S)	ppm	109.90	726.70	796.80	-	621.40	-	-	-	-	-	-
Phosphorus (P)	ppb	190.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Silicon (Si)	ppb	840.00	23.00	18.00	26.00	200.00	21.00	190.00	110.00	130.00	145.69	227.48
Lithium (Li)	ppb	106.00	294.00	315.00	158.55	372.00	132.48	149.07	137.37	134.42	166.73	143.60
Iodine (I)	ppb	19.30	39.98	58.02	66.47	14.72	68.22	62.27	71.32	48.06	9.60	41.30
Barium (Ba)	ppb	11.00	3.00	3.00	5.53	4.63	3.31	5.26	5.25	6.74	3.26	2.73
Manganese (Mn)	ppb	22.00	0.00	0.00	0.47	0.00	0.77	2.82	0.73	0.97	0.00	0.00
Iron (Fe)	ppb	18.00	0.00	3.00	0.00	0.00	0.00	0.00	1.49	0.00	0.00	0.00
Molybdenum (Mo)	ppb	1.00	4.00	3.00	10.35	8.95	9.11	10.05	9.15	9.04	9.63	9.49
Zinc (Zn)	ppb	0.00	0.00	0.00	15.47	1.00	16.62	15.86	9.24	102.41	0.00	1.83
Copper (Cu)	ppb	0.00	0.00	2.00	-	6.00	-	-	-	-	-	-
Aluminium (Al)	ppb	11.00	35.00	28.00	-	48.00	-	-	-	-	-	-
Arsenic (As)	ppb	24.00	20.00	10.00	-	7.00	-	-	-	-	-	-
Tin (Sn)	ppb	0.00	0.00	0.00	0.02	0.00	-	0.04	0.02	-	0.00	0.00
Antimony (Sb)	ppb	0.00	0.00	0.00	0.18	0.45	0.21	0.19	0.22	1.86	0.54	0.22
Cadmium (Cd)	ppb	0.00	0.00	0.00	0.05	0.05	0.05	0.07	0.03	0.17	0.00	0.00
Tungsten (W)	ppb	0.00	1.00	0.00	0.09	0.06	0.09	0.10	0.09	0.02	0.00	0.00