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# Amazing level of bromine found in Lonar crater water ecosystem, Maharashtra, India

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## Abstract

*The salt of Lonar Crater water body was tested by XRF analysis, which showed very high content of Bromine (Br), higher than the sea, ocean Dead sea or any other fresh water body. Bromine (Br) content in Lonar salt was found to be 5.5 mass %, Bromine (Br) is one of the rare elements among the halogen group elements. It is mostly associated with other halogen group elements like Chlorine (Cl) and Iodine (I). Our findings is that amongst halogen group element, the first highest is Chlorine and the second highest is Br, found in Lonar crater water system and the first highest in all the water bodies existing on the earth. In other wsords it can be said that Lonar Crater is halogen group dominated water body. This paper reports the first hand information about detection of Bromine (Br) in very high concentration, in the waters of Lonar Crater, which is higher than the marine water body and fresh water body existing on the surface of the earth and to put on records, the findings of high content of Br in Lonar Crater water system on preliminary basis.*

**Keywords:** Lonar crater, water system, bromine content, sea water, dead sea.

## Introduction

At Lonar a depression was formed due to meteorite impact. The co ordinates of this depression is 19°58'N and 76°30'E. This depression is referred as meteorite impact crater, which is in Buldhana District of Maharashtra. The circumference of this crater is approx. 5.7462km, its diameter is 1.83km approx. and the depth is 150mtrs approx. The raised rim of the crater is well preserved. The crater is filled with water of saline and alkaline nature. The color of the water is found to be green due to algae. The water of the lake increases at the time of rainy season and decreases after the rainy season. During the summer season the temperature is found to be around 44-45°C.

**Some of the earlier works carried on Lonar Crater:** Studies of ground water percolation river lets from inner portion of the crater carried by Komatsu and others concluded that the ground water movement is regulated by lithological processes[1]. From the analyses and observations carried out by Shinde and More concluded that the alkalinity of Lonar Lake is decreasing, the pH was found to be between 8.4 to 9.5, the elements such as Calcium, Magnesium, and Sodium were found to be minimum, due to which, the salinity of the soil is found to be low[2]. The level of pH found to decrease in monsoon period; Borul concluded that because of alkali elements dilution in monsoon, resultant of turbidity increase of the water body and successively decreases due to process of photosynthesis by green pigmented plants[3]. The investigations and studies carried by Nandy and Deo and observations made confined that the formation of Crater Lake could not be conclusive regarding the origin of Crater Lake[4]. The studies conducted by Pawar states that due to the results of unchecked sewage flow, Lonar Crater is coming under threat, thereby increasing the level of Lake Water and decreasing its salinity level. These changes can affect bio diversity or ecosystem[5]. Treatment of unsafe water is being carried out by different communities and private sectors as found from the studies carried out by Gaikwad and Sasane and state that looking at it as a whole; it is observed that combination of these may develop in near future, which may solve the problem of rural water treatment[6]. Studies of Ostrapods carried out by Badve et al through SEM analyses from the marshy areas showed that diatoms are also present on the internal carapaces and also were found to occur in surrounding waters[7]. The studies carried out by Anthony et al. of Crater Lake, concluded that the soda lake ecosystems consisting of microbial diversity has not only been helpful to understand the limits of life existing at extreme pH, but it can also be helpful to search for other useful biomolecules[8]. Siddiqi and others studied crater water body and concluded that, it is of utmost important to preserve and protect the uniqueness of Lonar Crater by all means[9]. Chakrabarti and Basu carried out Pb isotopic analyses of rocks of Lonar Crater and concluded that the breccias formed by impact are found to show fragmented chondritic-normalised, trace elemental structures, when considered with respect to original basaltic rocks[10]. Sarkar et al. while doing studies on secondary quartz stated that the present study shows that changes in eastern position of crystallographic indexing of planar deformational characteristics needs to be done in detail[11].

## Methodology

Water sample from Crater water body were collected in two plastic bottles washed thoroughly by the same water to study its chemical properties. The water was kept in an open steel plate, sides little raised up, and this plate was kept in the sun for evaporation. After 5-6 days, when all the water was evaporated, the salts left in the steel plate were collected, crushed in a motor pestle made into powdered form and kept in a plastic box for further analysis. Along with this sample sea salt was also taken for comparison. The sea salt was taken from salt pans site, between Vashi and Vadhav, Tal. Pen, District Raigad, Maharashtra. This is because analysis of Lonar salt through physico-chemical and XRF shows that Lonar Lake salt and sea salt shows similarity[12].

**Scope of work:** Uses of Bromine: It is used as a sanitizers and disinfectant, insecticides, germicides, fungicides and pesticides. Compounds of Bromine are important for industries and pharmaceuticals. If it can be possible to extract Bromine (Br) from Lonar crater water body, it will be economically important and helpful to manufacture Bromine compounds for Industrial and Pharmaceutical uses.

**Observations:** Lonar salts appearance muddy white, amorphous in nature, opaque. After evaporation a thin paper like formation was observed, non hygroscopic. Sea salt appearance white, small crystals formation observed after evaporation, hygroscopic in nature, opaque.

**Experiments:** The salts under study after crushing into powdered form, was sent for physicochemical analyses. After this the powdered salt samples was sent for XRF analysis.

**Experimental results:** The results obtained by physicochemical analyses from Table-1, shows that pH of Lonar salt is 10, which is highly alkaline. XRF analysis shows that chlorine (Cl) content is found to be 45.579 mass %, which shows that chlorine (Cl) content is also very high. The results obtained by XRF analysis of powdered samples under study shows that in Lonar Crater water system, NaCl value is 75.138 mass % and Br is 5.5 mass %, whereas sea salt pH is found to be 7.5, XRF analysis shows that Chlorine (Cl) content was found to be 42.884 mass % and Br was found to be 0.683 mass % .

## Results and discussion

From the analysis report Table-2, it is observed that Br content is 5.5 mass %, which is found to be highest and topmost content amongst all the water bodies in the world, in other words, it can be said that there is no water body existing on the earth's surface showing such a high concentration of Br as that detected in Lonar crater water system, so it is amazing and strange about Lonar crater water system showing this high % of Br, where as in the Sea water, natural composition is found to be 0.683 mass % as per this study, which shows that in Lonar Crater water system, Br is eight times higher than the sea water and the Dead Sea contains 5g/L[13]. From this it infers that the world famous Dead Sea, the only high content of saline water, contains less Br than Lonar water system, which is one and the first of its kind on the Earth surface containing highest percentage of Br. Hence one can imagine how the bio diversity or biological community developed, advanced and genetically modified which has adapted abnormal ecosystem existing at Lonar crater, which may not be found existing anywhere on the earth's surface water body. The ratio of Cl:Br in Lonar salt is found to be 8.29, whereas the ratio of sea salt is found to be 62.79, the ratio difference of Cl:Br between Lonar salt and sea salt is found to be 54.50. A Major difference is observed.

**Table-1:** Physicochemical analysis of Sea salt and Lonar salt.

| ↓Parameters/Salt→ | Common Salt NaCl | | Lonar Salt | |
|---|---|---|---|---|
| | Results | Unit | Result | Unit |
| pH (10% solution) | 7.5 | | 10 | |
| Sulphate | 5002 | mg/kg | 17676 | mg/kg |
| Chloride | 60904 | mg/kg | 298200 | mg/kg |
| Conductivity | 90.9 | ms/cm | 78.4 | ms/cm |
| Salinity calculated from chloride value | 109.93 | g/L | 538.25 | g/L |
| TDS calculated from conductivity value | 133676 | | 115294.12 | |
| Hardness | 39026 | mg/kg | 7006 | mg/kg |
| Alkalinity | 488 | mg/kg | 323529 | mg/kg |

Remark: All above results excluding pH are on dry weight basis.

**Table-2:** Oxide composition of Lonar salt and sea salt by XRF in mass %.

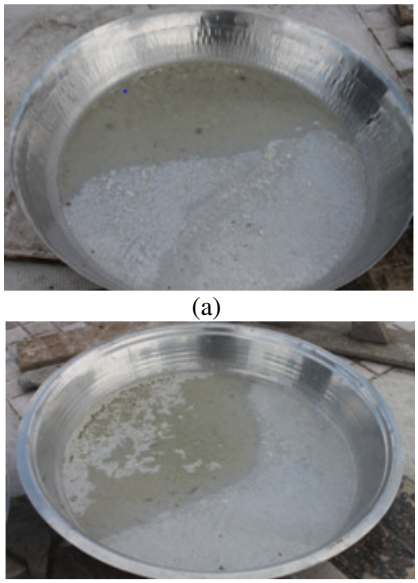
| Salts | Sea salt (Common salt) | Lonar salt |
|---|---|---|
| Formula | | |
| NaCl | 70.695 | 75.138 |
| Oxides | | |
| $SO_3$ | 16.704 | 8.621 |
| $K_2O$ | 2.203 | 3.687 |
| CaO | 9.168 | 3.72 |
| $Fe_2O_3$ | 0.548 | 3.334 |
| Br | 0.683 | 5.5 |
| Total | 100.001 | 100 |

**Table-3:** Elemental composition of Lonar salt and Sea salt by XRF in mass %.

| ↓Elements/Salts→ | Sea salt (Common salt) | Lonar Salt |
|---|---|---|
| Formula | | |
| Na | 27.811 | 29.559 |
| S | 6.689 | 3.452 |
| K | 1.829 | 3.061 |
| Ca | 6.552 | 2.659 |
| Fe | 0.383 | 2.332 |
| Br | 0.683 | 5.5 |
| Cl | 42.884 | 45.579 |
| O | 13.169 | 7.858 |
| Total | 100 | 100 |

**Table-4:** Comparison of Bromine (Br) content in salts.

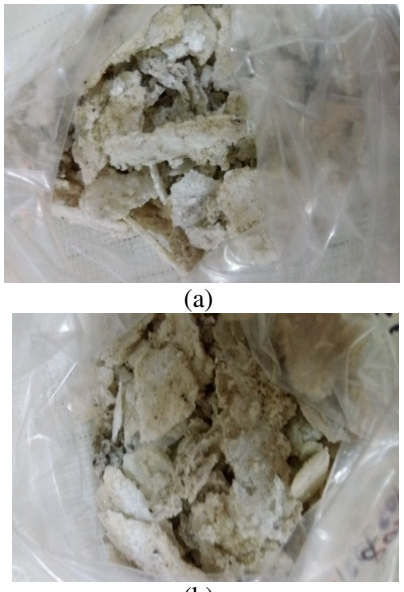
| Name of water body | Bromine (Br) content |
|---|---|
| Lonar Crater | 5.5 mass % |
| Sea | 0.683 mass % |
| Dead Sea | 5 g/L[13] |



(a) (b)

**Figure-1:** (a) and (b) Lonar Lake water kept for evaporation, salt formation is seen.

**Figure-2:** Sample of sea salt (NaCl).



(a) (b)

**Figure-3:** (a) and (b) Complete salt formation after evaporation of Lonar Crater water.

Br in rock samples of Lonar has been reported by Son and Koeberl, which are found to be in trace quantity[14]. Br found in the earth's crust and in extra terrestrial body (meteorites) is in trace quantities. But it is found in higher concentrations in Lonar Crater water system which is amazing. Let's consider that extra terrestrial bodies (meteorites) is a source of high content of Chlorides and Bromides, but this assumption cannot be accepted or true because meteorite studies shows that no such kind of meteorites fallen on earth surface which is made up of only Cl, Br or halogen group elements showing such a high content. And if it is, then how can halogen group elements sustain from that time till date?

At Lonar Crater, water analyses have been carried by different researchers and they have reported chlorides and fluorides, but detection of Br has not been reported. Findings of Br in percentage are surprising, because except the Dead Sea, Br has not been found or detected in any water body. Findings of bromine are associated with Cl and F, because Cl has been detected[2-7]. Flourine (F) has also been detected[2]; hence it is natural that Br may also be present because halogen group elements are usually found in groups. They are not found freely in nature. They are always found in combined state with other elements forming salts. These halogen group elements are mostly found in the seas and oceans. The highest percentage of bromine found on the earth surface is in the Lonar Crater water system. The second highest percentage of bromine detected may be the Dead Sea. As suggested in our earlier paper on high content of NaCl can be leachate out from below the basaltic lava flows, which lay buried underneath, the remains of an ancient sea bed[12]. Despande has mentioned that in the Purna alluvium occurrence of salt in some beds below the surface has been observed. In areas of Purna river on both sides from Dahihanda, north of Akola, about 45 km from Amravati in a band of gravel clays, at a depth of 40meters, presence of brine has been reported. The presence of salt is indicative of a marine bed below[15]. This is strong evidence that supports our assumption explained in our earlier paper (A search for the source of high content of sodium chloride NaCl at Crater Lake, Lonar[12]). It is possible that along with NaCl, Br may also leachate out from below the basaltic lava flows.

But the question still remains unanswered, how is it possible that high concentration of Br exists from the time the crater was formed till date? It is not possible. Br is very reactive halogen group element. It cannot sustain in any reservoir at such high concentration for a huge time scale, because Br is exhaustible by geochemical cycle. Br has two isotopes $^{35}Br^{77}$ and $^{35}Br^{81}$ and has a half life period of 57 hours[16]. Hence it cannot be present over huge time period. How is it possible that it is still showing its high concentration or its appearance in the waters of Lonar? Lonar Crater water system contains variety of salts and chemicals which may have come from various known and unknown geological events which may have occurred in prehistoric times and unknown viz. i. Volcanic eruption of 65ma pouring out basalts in large quantities all over Maharashtra. ii. Meteorite impact forming depression some 656Ka[17] at Lonar. iii. Unknown events which remains buried are preserved or existing in Lonar Crater water system. Some of these chemicals species are very reactive, but still they remain there in abnormal concentrations or higher concentrations, their chemical tendency has not exhausted or deteriorated as time passed.

Fortunately Lonar Crater water body salt contains very high concentration of Chlorine (Cl) as one of the halogen group element among the other water body existing on the earth. So, Bromine (Br) always associated with halogen group elements, under influence of this, high content of Cl, increases the concentration of Br by natural process.

**Environmental Impact:** If such huge amount of Br, and microbial activity, and metabolic product of the entire organisms, may release Br compounds, which is equally hazardous like Chlorine (Cl), which can deplete Ozone ($O_3$) layer. Br is highly corrosive in nature and can cause damage to living tissues.

## Conclusion

From the analysis of Lonar salt by XRF, the discussions and by comparing it with sea salt which shows some resemblance and the Dead Sea, it can be concluded that the salt of Lonar Crater water system contains high percentage (%) of Bromine (Br) as compared to the salts of marine water body and sweet water body in the world. The possibility of Br coming to the water body may be through metabolic product of microorganisms.

**Importance of work:** It is a challenge to search how Br being very reactive halogen group element can sustain in Lonar crater water body at a higher concentration for such a large time span, being exhaustible and having 2 isotopes with half life period of 57 hours and is still showing its existence? This question remains unanswered. Further studies are in progress.

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