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Analysis of physico- chemical parameters of SuryaKund, a hot water spring at Hazaribagh district, Jharkhand: comparison with nearby sources of freshwater

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KEYWORDS

Thermal spring, Surya Kund, Physico-chemical Properties, DCO2, Jharkhand, Flora

ABSTRACT

Physico-chemical properties not only reflect the quality of water but also accounts for the flora and fauna inhabiting the habitat. Hot spring/ Thermal Spring is a natural phenomenon generated by the rise of geothermal heated groundwater on the surface of earth. Amongst approximately 60 hot springs in Jharkhand, SuryaKund is the hottest spring located in Barkatha road, Barhi, Hazaribagh, Jharkhand. In the present study, water was collected from boiling (K1; group II) as well as hot regions (K2; group III) of SuryaKund along with a Handpump situated 500 m away from the Kund (K3; group IV) and their characteristic were compared with normal tap water collected from Department of Zoology, St. Xavier's college, Ranchi (C; group I). The water was tasted for Temperature, pH, TDS, EC, ORP, Salinity, Alkalinity, DO, DCO2, Calcium, Chloride, Magnesium and Sulfur following routine laboratory methods and digital pH pen meter. Data were obtained in triplicate and analyzed statistically using Student's t-test. Boiling water of SuryaKund was estimated to have highest temperature and pH and lowest TDS, ORP, DO and DCO2 among all the water sample collected. Calcium content was found to be significantly higher in water sample of group II, III and IV, suggesting for its therapeutic effect on bone and cardiovascular health. Presence of higher level of magnesium in boiling water of SuryaKund advocated for its benefit in neural, muscular and cardiovascular health. However, further detailed scientific enquiry is warranted to explore its therapeutic efficacy and bacteriology.

List of abbreviations:
DCO2: Dissolved carbon dioxide
DO: Dissolved oxygen
EC: Electrical Conductivity
ORP: Oxidation Reduction Potential
pH: Potential of Hydrogen
TDS: Total Dissolved Solid

1. INTRODUCTION

Water is the second most vital element for life after air. Due to its Significance for life, water quality has been widely studied in scientific research. Water quality is commonly defined as the physical, chemical and biological properties of water. It indicates the condition of water in relation to the needs of living organisms and its suitability for human use or specific purposes [1]. Water is an essential component of all ecosystems, as all living organisms require it for survival, growth, and metabolic activities. The availability of good quality water is crucial for maintaining public health preventing diseases, and improving overall quality of life [2]. Water quality is traditionally characterized by its physical, chemical and biological dimensions while chemical parameters facilitate the identification of inorganic substances and soluble organic salts, physical properties are fundamental in establishing the visual and tactile profile of the water source [3]. Water plays a vital role in controlling ecosystem dynamics through a two-way interaction. The quality and quantity of water influence the characteristics of an ecosystem, including its biodiversity, species richness, evenness, resilience, and evolutionary patterns. The structure and functioning of an ecosystem, in turn, determine the quality of water produced within it [4]. Water quality parameters of natural reservoirs have been studied by various researchers [2, 5, 6]. Assessment of water quality parameters has also been of much importance in case of laboratory experiments of toxicology [7]. A detailed knowledge of the physico-chemical properties of water not only helps in identification of current status of flora and fauna, but also helps in prediction of their condition in future.

Hot springs water is a natural phenomenon known as Thermal Spring. Hot spring is generated by the rise of geothermal heated groundwater on to the surface of the Earth [8]. In Jharkhand, there is documentation of approximately 60 Thermal Hot Springs. Some of them are summarized in table 1.

Table 1: Sources of hot water in Jharkhand [9-12]

Sl. No.	Name of the reservoir	Location	Key features and activities
1.	SuryaKund	Barkatha, road, Barhi, Hazaribagh.	• Natural geothermal hot spring with sulphur-rich water. • Known for its medicinal and therapeutic properties • Many people believe bathing in the water helps skin diseases and body pain. • Water temperature ranges around 80-87°C, making it among the hottest springs in India. (Jharkhand Forest Department)
2.	Tatloi	Near Barapalasi, in Jama block, Dumka	• Natural geothermal hot spring with continuously flowing warm water. • This hot water spring has a mixture of sulphur and other medicinal elements; it helps to cures all skin diseases. (Government of Jharkhand, Dumka)
3.	Tata Pani	Near Barwadih, in Latehar district.	• Natural geothermal hot spring with warm water emerging from underground rocky surfaces, surrounded by forests and natural landscapes. • This spring contains sulphur and dissolved minerals, beneficial for skin diseases and joint pain. (Jharkhand forest department)
4.	Balbal	Near Dawari village, in Chatra, Hazaribagh	• Natural geothermal hot water spring with continuously flowing warm water throughout the year. • Water contains sulphur and other minerals with therapeutic value. (Department of Forest, environment and climate change)

AIM OF THE STUDY:

In the present study, an effort has been made to analyze various physico-chemical parameters of the water collected from SuryaKund and compare them with the water sample collected from other sources of freshwater in vicinity.

MATERIALS AND METHODS:

Collection of Samples

Water samples were collected from four different locations and categorized into four groups:

- **Group I (C):** Water collected from the PG Department of Zoology, St. Xavier's College, Ranchi.
- **Group II (K_1):** Water collected from the boiling region of SuryaKund, Barkatha Road, Hazaribagh, Jharkhand.
- **Group III (K_2):** Hot water collected from a nearby Kund located adjacent to the boiling water source.
- **Group IV (K_3):** Water collected from a hand pump situated approximately 500 meters away from the Kund.

The water samples collected from SuryaKund and nearby areas were tested on-site for **temperature and pH**. All samples were collected in thermo-steel bottles and transported to the Post Graduate Department of Zoology, St. Xavier's College, Ranchi, for further analysis.

Fig. 1. Collection sites (a) Boiled water (b) Warm water

Estimation of Physico-Chemical Parameters

The following physico-chemical parameters were analysed for all four groups of water samples: Temperature, pH, TDS (Total dissolved solid), Electrical conductivity, Salinity (Oxidation reduction potential), Dissolved Oxygen (DO), Dissolved Carbon Dioxide (CO_2), Chloride Ion Concentration, Alkalinity, Calcium ion, Magnesium ions, Sulphur ions.

Table 2: Methodologies adopted for the physicochemical studies [5]

Sl. No	Parameters	Methodology adopted
1.	Temperature	Thermometer
2.	pH	pH pen meter
3.	TDS	pH pen meter
4.	Electrical conductivity	pH pen meter
5.	Alkalinity	Titrimetric method
6.	Salinity	pH pen meter
7.	Oxidation Reduction Potential (ORP)	pH pen meter
8.	Dissolved oxygen	Winkler's method
9.	Dissolved carbon dioxide	Titrimetric method
10.	Chloride	Titrimetric method
11.	Calcium	Titrimetric method
12.	Magnesium	Titrimetric method
13.	Sulfur	Spectrophotometric

Statistical analysis

All the tests were done in triplicate. Data obtained were expressed as mean ± S.D (standard deviation). Data were statistically analysed using student's *t*-test to show significant differences among them. $p < 0.05$ was considered as significant.

Results and Discussion

In the present study, water sample was collected from tap water at St. Xavier's College Ranchi (Group I), Boiling region of SuryaKund, Barkatha Road, Barhi (Group II), hot water from nearby region of main boiling Kund (Group III) and a handpump situated approximately 500 m from the Kund (Group IV). The physico-chemical characteristics of all the collected water sample are summarized in Table 3 .

Table 3: Physico-chemical parameters of water sample collected from different sites.

Parameters	**I (C)**	**II (K_1)**	**III (K_2)**	**IV (K_3)**
Temperature (°C)	26.8 ± 0.70	86.98 ± 0.33***	41.72 ± 0.42***	26.56 ± 0.57
pH	5.60 ± 0.24	7.37 ± 0.04***	6.99 ± 0.10 **	6.54 ± 0.13
TDS (ppm)	440 ± 16.46	359 ± 4.58**	388.67 ± 1.53*	241.33 ± 3.21***
EC (µS/cm)	880.33 ± 38.89	718 ± 11.14**	776.67 ± 1.53*	482 ± 6.08***
Alkalinity (mg/L)	7.1 ± 0.52	5.97 ± 0.29	0.13 ± 0.06***	0.1 ± 0.00**
Salinity (%)	0.04	0.03	0.03	0.02

	± 0.00	± 0.00	± 0.00	± 0.00
ORP (mV)	301.67 ± 19.66	202.67 ± 27.47*	233 ± 9.54*	250.67 ± 6.03*
Dissolved Oxygen (mg/L)	0.23 ± 0.06	0.17 ± 0.06	0.17 ± 0.06	0.33 ± 0.12
DCO_2 (mg/L)	0.20 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.27 ± 0.06
Chloride (mg/L)	12.97 ± 1.59	6.37 ± 0.76**	8.5 ± 0.52*	4.07 ± 0.55**
Calcium (mg/L)	9.73 ± 2.19	10.5 ± 1.47	13.1 ± 3.41	11.97 ± 4.24
Mg (mg/L)	0.00 ± 0.00	6.17 ± 0.76	2.03 ± 0.06	0.00 ± 0.00
Sulfur (mg/L)	0.09 ± 0.00	0.08 ± 0.00*	0.01 ± 0.00***	0.09 ± 0.00

Data presented as mean ± S. D. *p<0.05, **p<0.01, ***p<0.001.

Temperature and pH

The boiling water collected from SuryaKund was having highest temperature (86.98 ± 0.33°C) and pH (7.37 ± 0.04) among all the water samples collected (Fig 2). An increase in temperature was due to the groundwater being heated up by intrusion of magmatic bodies [13]. An increase in pH of hot water spring (Fig 4) indicates greater alkalinity, because geothermal water interacts with the underground minerals and rocks for a prolonged period before reaching the surface, resulting in the dissolution of bicarbonate, carbonate, silicate, and other alkaline constituents [14].

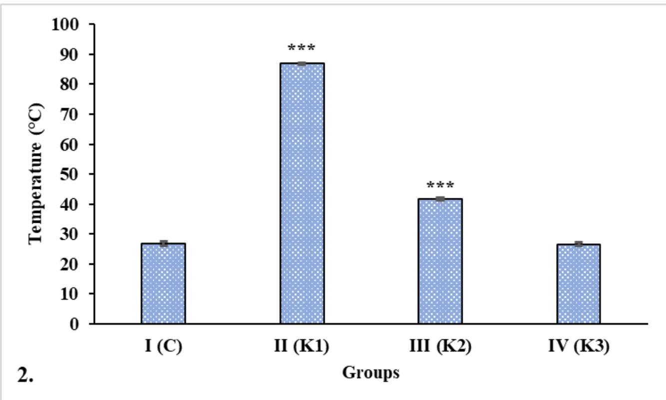

Fig.2: Graph showing variation in temperature of water collected from different sites (*p<0.05, **p<0.01, ***p<0.001).

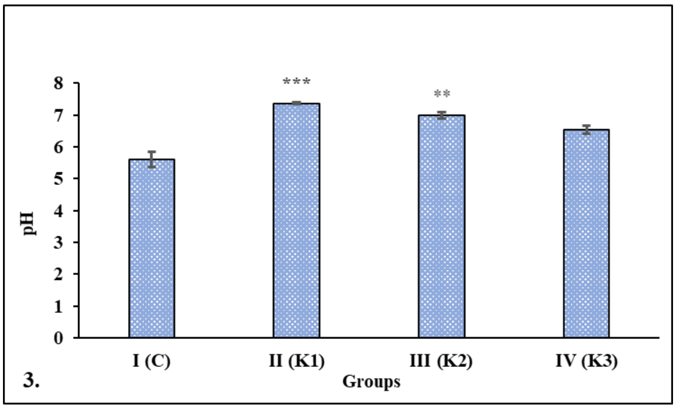

Fig. 3: Graph showing variation in pH of water collected from different sites (*p<0.05, **p<0.01, ***p<0.001).

TDS and EC

Normal tap water collected from St. Xavier's College; Ranchi was having highest TDS (440 ± 16.46 ppm), and Electrical conductivity (880.33 ± 38.89 μs/cm) among all the water samples collected (Fig 4 and 5). TDS commonly reflects to the total amount of dissolved salts and minerals, present in water. TDS concentration of boiled water and warm water was lower than that of tap water, indicating a relatively lower concentration of dissolved minerals. Low TDS observations in geothermal springs have been linked to high water-to-rock ratios and relatively inert lithology, resulting in decreased dissolution of ionic constituents [15]. The lower EC observed in boiled water and warm water when compared to tap water may be due to the precipitation of dissolved minerals during heating and boiling, which reduces the concentration of free ions responsible for EC. Electrical conductivity is directly proportional to the concentration of dissolved ions [16].

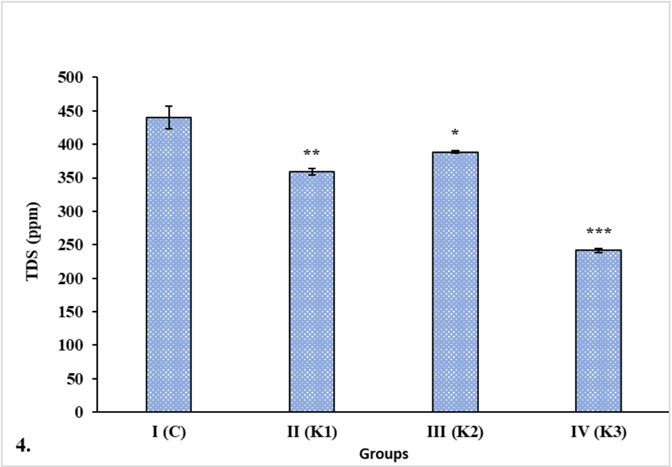

Fig. 4: Graph showing variations in TDS of water collected from different sites (*p<0.05, **p<0.01, ***p<0.001).

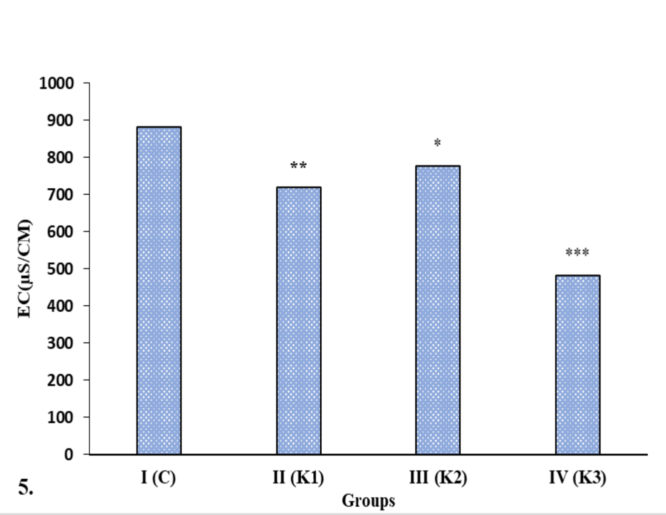

Fig. 5: Graph showing variation in Electrical conductivity of water collected from different sites (*p<0.05, **p<0.01, ***p<0.001).

Alkalinity, Salinity and ORP

In tap water observe in highest Alkalinity test and lowest in boiled water, warm water, and handpump water. This decrease in alkalinity of boiled and warm water was due to thermal decomposition of bicarbonates, release of dissolved CO_2 and precipitation of carbonate minerals during heating. Also, lower alkalinity of handpump water may be associated with reduced bicarbonate, carbonate concentration [17]. Water of control group was having highest Salinity (0.04 ± 0.00 %) and ORP (301.67 ± 19.66 mV) among all the water samples collected. The lower salinity observed in boiled and warm water may be due to dissolution of soluble minerals and limited dilution by meteoric water, resulting in a lower concentration of dissolved salts [15]. The ORP value of boiled and warm water was lower than the tap water, showing more reducing conditions in the hot spring water. This decrease in ORP may be due to the presence of reduced chemical constituents. The decreased dissolved oxygen concentration can be associated with high temperature and boiling. Lower oxygen availability reduced the oxidizing capacity of water, thereby lowering its oxidation reduction potential [18]. The ORP value of handpump water was lower than that of tap water, indicating relatively reducing conditions in the groundwater source. This may be attributed to lower dissolved oxygen concertation and the presence of reduced chemical species such as ferrous iron, Manganese, and organic matter in groundwater [18].

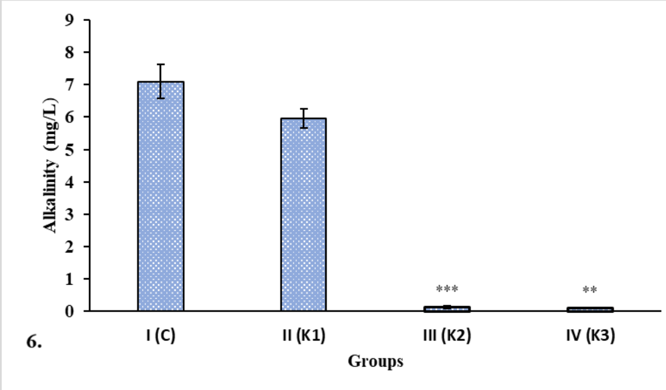

Fig. 6: Graph showing variation in Alkalinity of water collected from different sites (*p<0.05, **p<0.01, ***p<0.001).

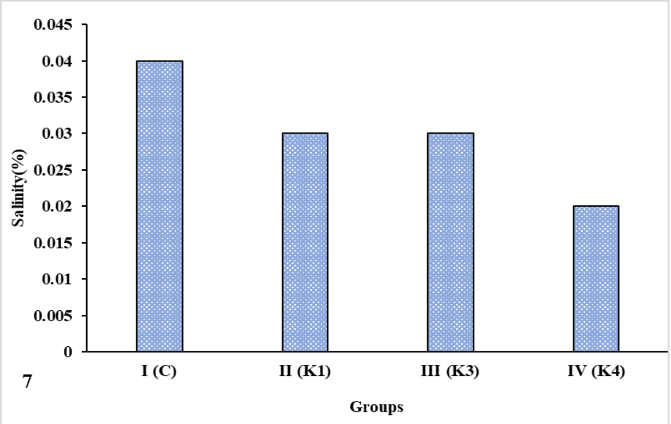

Fig. 7: Graph showing variation in salinity of water collected from different sites

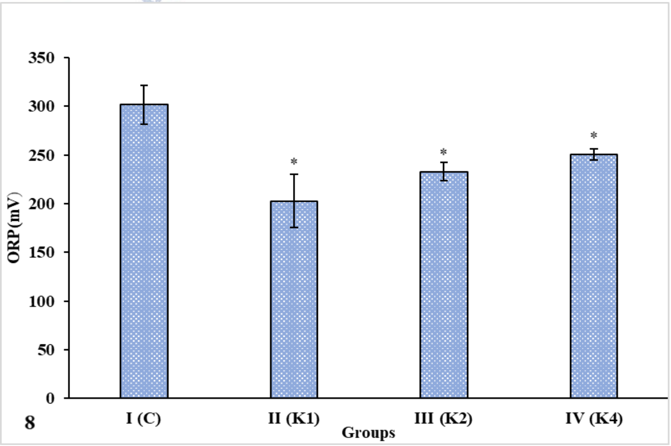

Fig. 8: Graph showing variation in oxidative reduction potential of water collected from different sites (*p<0.05, **p<0.01, ***p<0.001).

DO and DCO₂

Handpump water collected from approximately 500 meters away from the Kund was having highest Dissolved oxygen (0.33 ± 0.12 mg/L) and Dissolved carbon dioxide (0.27 ± 0.06 mg/L). The Dissolved Oxygen concentration was higher in handpump water than in tap water, which may be associated with groundwater recharge processes and aeration during pumping. The higher concentration of DCO_2 in handpump water compared to tap water may also be due to the infiltration of CO_2 produced by soil respiration and microbial decomposition into groundwater. Under sub-surface conditions, elevated pressure and limited gas exchange with the atmosphere enhance the dissolution and retention of CO_2 in ground water. In contrast, warm and boiled water samples exhibited lower DO concentration due to the reduced solubility of oxygen at elevated temperature and the release of dissolved gases during heating and boiling [19]. On the other hand, dissolved CO_2 is absent in boiled and warm water because the solubility of gases decreases with increase in temperature [20].

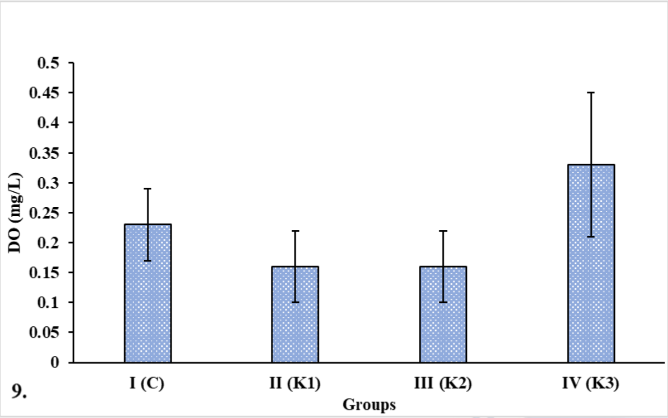

Fig. 9: Graph showing variation in dissolved oxygen of water collected from different sites.

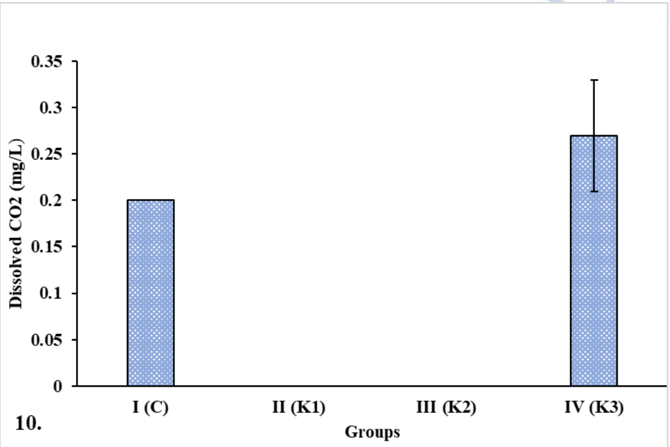

Fig. 10: Graph showing variation in Dissolved CO2 of water collected from different sites

Chloride, Calcium, Magnesium and Sulfur

The Concentration of chloride in boiled water, warm water and handpump water was less than the tap water. This difference may be due to natural groundwater recharge, hydrothermal dilution, water-rock interaction and negligible anthropogenic influence in the hot water spring and handpump water [21]. The increased level of calcium concentration observed in warm water (13.1 ± 3.41 mg/L) may be due to water-rock interactions. Although anthropogenic activities like bathing may slightly influence the physico-chemical parameters of warm water [22]. Magnesium was detected only in boiled water (6.17 ± 0.76 mg/L) and warm water (2.03 ± 0.06 mg/L). It was not observed in tap water and handpump water. The presence of magnesium in boiled and warm water may be associated with enhanced dissolution of Magnesium-bearing minerals under geothermal conditions and prolonged water-rock interactions [23]. Similarly, sulphate concentration was detected in tap water (0.09 ± 0.00 mg/L) and handpump water (0.09 ± 0.00 mg/L). Both water sources are controlled by the dissolution of sulphate-bearing minerals such as gypsum and anhydrite [20].

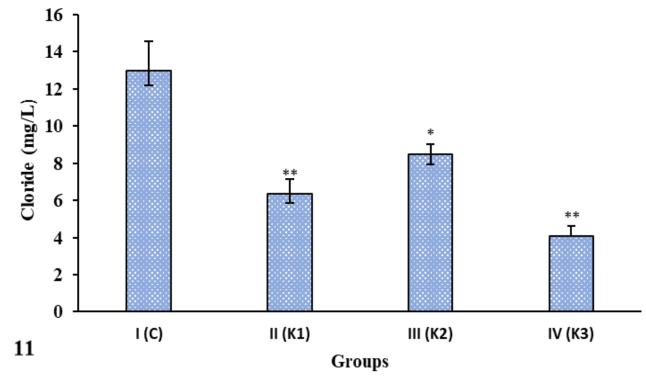

Fig. 11: Graph showing variation in chloride of water collected from different sites (*p<0.05, **p<0.01, ***p<0.001).

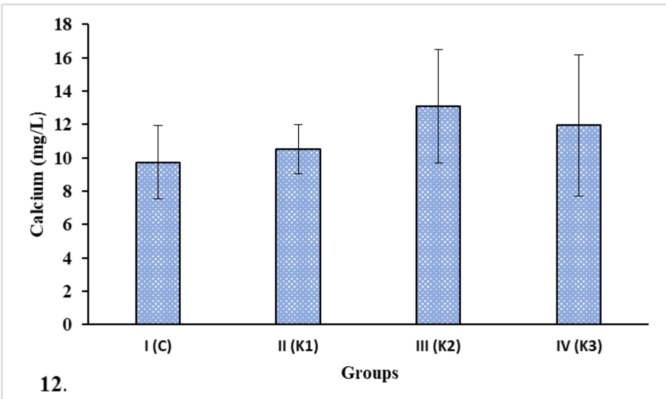

Fig. 12: Group showing variations in calcium of water from different sites.

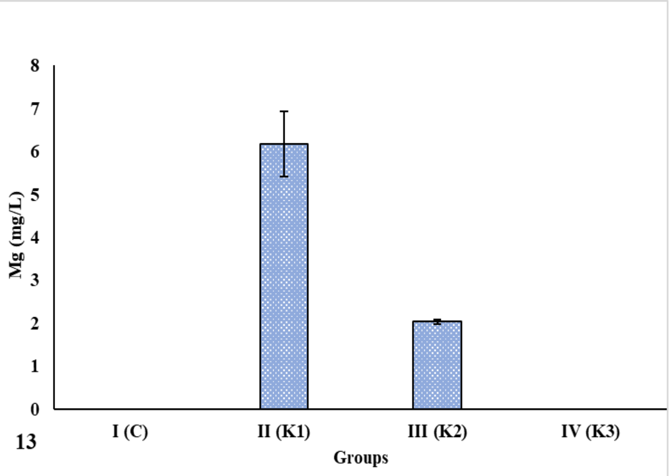

Fig. 13: Graph showing variation in magnesium of water collected from different sites

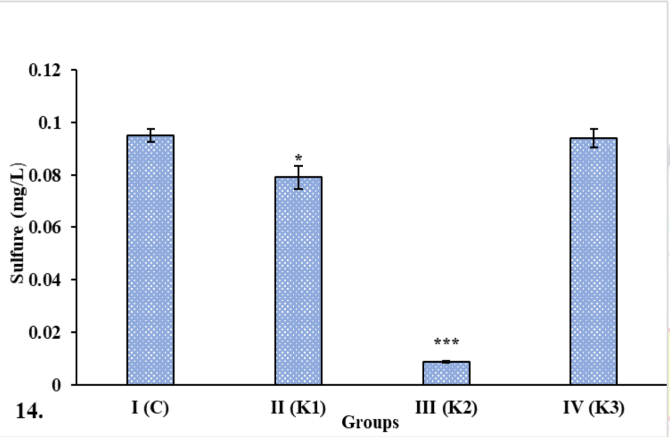

Fig. 14: Graph showing variation in sulfure of water collected from different sites (*$p<0.05$, **$p<0.01$, ***$p<0.001$).

CONCLUSION:

Warm water collected from the near by site of boiling region of SuryaKund was estimated to be rich in Calcium and Magnesium. These finding suggests for the healing effect of water from SuryaKund in terms of Bone mineralisation, Acid-base balanced in blood, Arthritis, Cardiovascular diseases, neural and muscular health as well as diseases of digestive track. Further scientific studies on the bacteriology and pharmacology activity of this water are required.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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