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Physicochemical and Heavy metals-contents Analysis of hot springs water in Khandesh province of Northern Maharashtra for balneotherapy.

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Abstract
Geo-Pharmacology is an emerging and novel branch of research in health geography. the word Geo-Pharmacology consist, one is Geography and second is Pharmacology in which Geographical components and elements are studied from pharmaceutical and medicinal point of view these points of views are useful for the wellness of human being so hot spring is one of the core components of Geo-Pharmacological research. Khandesh is province of Maharashtra state India .[1][2]
This region having reach Geo-heritage from ancient era and hot springs are one of them, these are Ramtalav hot spring 21°16'58"N 75°24'31"E,Unapdev hot spring,21°15'57"N 75°25'52"E,Anakdev ,21°43'47"N 74°26'31"E .[3][4] for the research study , hot springs water samples were collected fromRHS1,UHS1,and AHS1 hot springs chemicals tested physicochemical as well as heavy metallic contents were computed as pH was recorded 7.37,7.65,7.68 respectively, with salinity as 131,138 and 142.28 . so, all three came under as alkaline hot springs in nature. The correlation coefficients reveal perfect positive correlations (1.000) for temperature across RHS1, UHS2, AHS3, crucial for Balneotherapy efficacy. Negative correlations (-0.316 to -0.707) between temperature and total solids, T.D.S, and T.S.S suggest higher temperatures associate with lower solid particle levels, impacting mineral content. A strong negative correlation (-0.894) in temperature and electrical conductivity,
While physicochemical analysis results reflect, unique physico-chemical composition for therapeutic uses for balneotherapy centres. International guidelines and standards of WHO,USA,EU,Newzeland ,Australia ,Japan and India on permissible limits of physic-chemical components in water as nearby threshold limits, On the basis of the high levels of certain inorganic compounds like Cl,PO4 ,SO4, Ca, Mg, Na, K. F, heavy metallic Compounds:Fe,Cr,Mn also determination is unique. Therefor present, study revels, higher potentiality in Khandesh province can be future hub for balneotherapy as well in health tourism province in India.

KEYWORD:
Geo-Pharmacology of Hot springs
Khandesh province
Physicochemical analysis
Therapeutic uses
Metallic contents
Balneotherapy

I. Introduction

The present research scenario is shifting from disciplinary research to multidisciplinary with crystallised applicability for human being. on this basic principle Geopharmacology is an emerging and novel branch of research in health geography. the word Geopharmacology consist, one is Geography and second is Pharmacology in which Geographical components and elements are studied from pharmaceutical and medicinal point of view this points of views are useful for the wellness of human being so hot spring is one of the core component of Geo-Pharmacological research.

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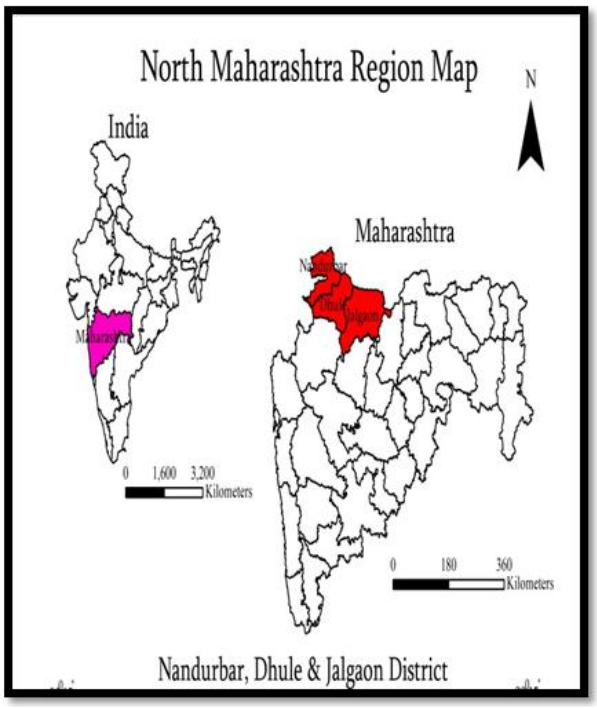
Geo-Pharmacology of hot springs in India, play and significant role in Indian cultural heritage as well as therapeutics benefits and natural beauty provinces of Maharashtra. Khandesh Region consist of three perennial hot spring name RamTalav, UnapDev, AnakDev of Northern Maharashtra. All these three hot springs have their socio-cultural as well Geo-pharmacological importance. Geologically Khandesh province is a basaltic flow of the Deccan trap. Geo-structurally, hot spring are situated along the dolerite dyke,faults and fractures almost parallel to the the strike line of southern Satpuda mountain foothills of river Tapi Valley.

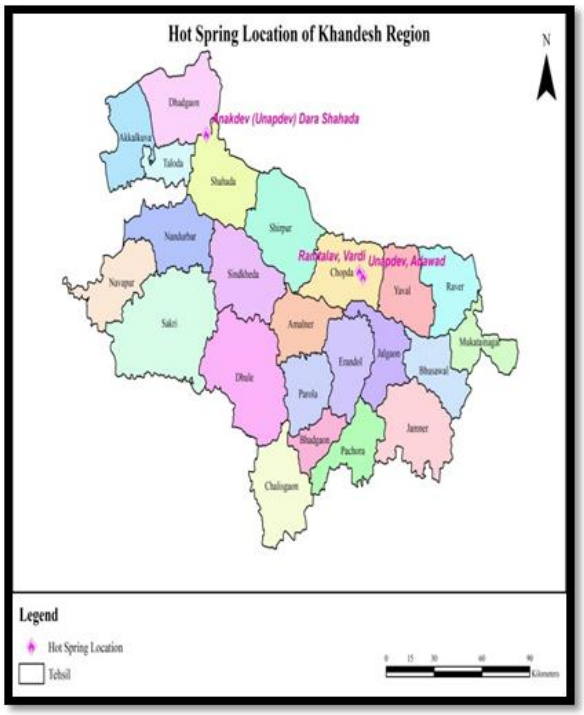
review of research show that hot spring of Unapdev, AnakDev studied for geothermal and thermostable enzymes, Phytonic diversity, Alkaline Protease Production and recreational and tourist point and curries that hot spring of Ramtalab was not study on any above dimension therefore prime core for present research is to analyses Physicochemical and Heavy metals-contents Analysis of hot springs water in Khandesh province of Northern Maharashtra for Balneotherapy .

Materials and methods

Description of sample site:

Hot springs in Khandesh region located at Unapdev(A) Hot spring, Adawad , 21°15'57"N 75°25'52"E, Ramtalav(B)hot spring ,Near





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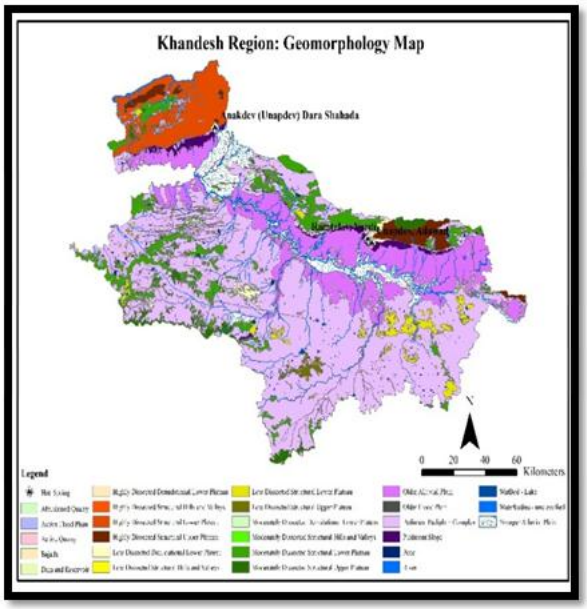

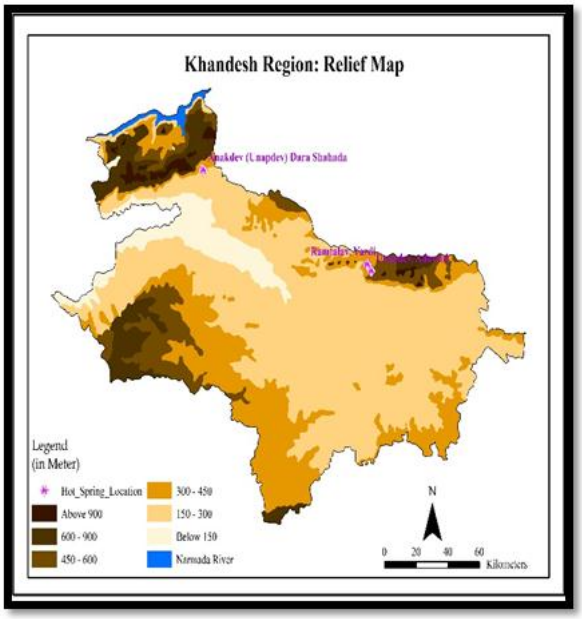

VardiVillage,Chopda 21°16'58"N 75°24'31"E ,Anakdev(C),DaraShahada ,21°43'47"N 74°26'31"E .[1] all these tree hot spring are situated along the dolerite dyke,faults and fractures with almost parallel to the strike line of southern Satpuda mountains foot hill of river TapiVally.[2]

Sampling of hot springs water in Khandesh:

The *in situ* temperature of hot springs water were Ramtalav(RHS1)is 47.3ºC, Unapdev(UHS2) is 58.0ºC and Ankdev(AS3) is 55.2ºC respectively. The hot springs water samples were collected in sterile conical flasks aseptically.[3][4] by using standard sampling protocols and were immediately transported to the Department of Microbiology, R. C. Patel Arts, Commerce & Science College, Shirpur. Dist. Dhule.affiliated to K.B.C North Maharashtra University,Jalgaon.(MH).

Physicochemical properties analysis

On the basis of temperature of Ramtalav (RHS1) is 47.3ºC, Unapdev (UHS2) is 58.0ºC and Ankdev(AS3) is 55.2ºC hot springs categories as hyperthermal hot springs on the other hand pH was recorded 7.37,7.65,7.68 respectively, with salinity as 131,138 and 142.28 . so, all tree came under as alkaline hot springs.

Hot springs in Khandesh	Temperature ˚C	pH	Salinity
Ramtalav Hot spring (RHS1}	47.3	7.37	131
Unapdev HS1(UHS1)	58	7.65	138
Anakdev HS1(AHS1)	55.2	7.68	142.28

Table:01

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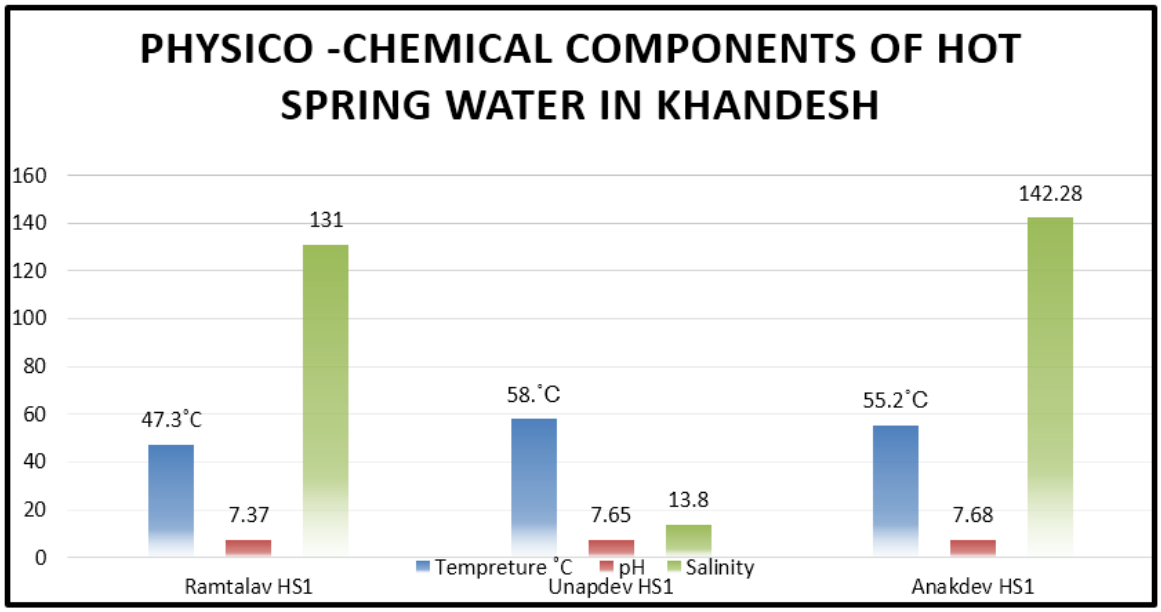
Graph: 01



Based on data: Ramtalav Hot Spring (RHS1) offers moderate temperature, slightly alkaline pH, and moderate salinity, suitable for gentle therapeutic experiences. Unapdev Hot Spring (UHS1) presents higher temperature, alkaline pH, and slightly elevated salinity, implying potential for enhanced muscle relaxation and skin benefits. Anakdev Hot Spring (AHS1) demonstrates warm temperature, alkaline pH, and the highest salinity, suggesting benefits for muscle relaxation, skin health, and detoxification. Each hot spring provides unique therapeutic advantages catering to diverse wellness needs.[5]

Correlation of hot springs in Khandesh region			
Hot springs properties	**RHS1**	**UHS2**	**AHS3**
Temperature	1	1	1
Total Solids	-0.31	-0.44	-0.44
T.D.S	-0.71	-0.71	-0.71
T.S.S	-0.25	-0.25	-0.25
Electrical Conductivity	-0.89	-0.89	-0.89

Table :02

The correlation coefficients for temperature across all three hot springs (RHS1, UHS2, AHS3) are perfect positive correlations (1.000), indicating high temperature consistency within each location, crucial for Balneotherapy efficacy. There are negative correlations between temperature and total solids, total dissolved solids (T.D.S), and Graph:02

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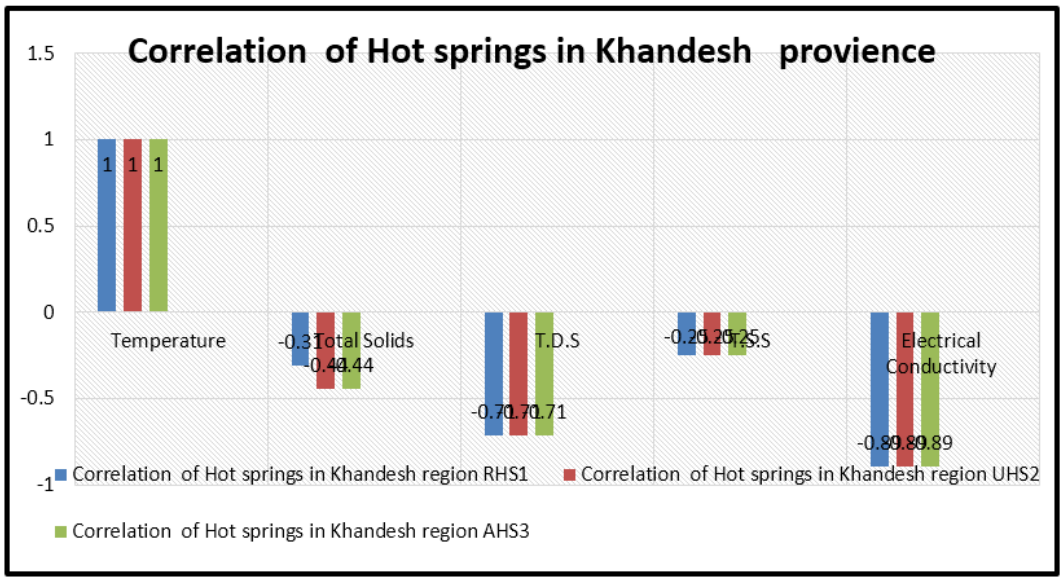

total suspended solids (T.S.S), with moderate to strong strengths (-0.316 to -0.707), suggesting higher temperatures associate with lower solid particle levels, impacting mineral content and therapeutic properties. Additionally, a strong negative correlation (-0.894) exists between temperature and electrical conductivity, indicating lower conductivity with higher temperatures, potentially affecting therapeutic effects.[6][7] These findings underscore the importance of temperature control and monitoring in maintaining therapeutic properties of hot springs for Balneotherapy and similar treatments.[8]

Ionic parameters analysis of hot spring water:

Sr.No.	Water Parameters	Methods	Ramtalav Hot Spring, (RHS1)	Unapdev Hot Spring (UHS2),	Anakdev Hot Spring, (AHS3)	Permissible limit by WHO
Ionic parameters						
1	Chloride	Argent metric	74.5	72	76	**250**
2	Phosphate	Stannous chloride	0.102	0.21	0.28	**---**
3	Sulphate	Turbidometry	134.44	42	44	**500**
4	Calcium	EDTA method	62.12	22.05	21.20	**75**
5	Magnesium	EDTA method	11.2	15.2	17.2	**30**
6	Sodium	Flame photometry	130.6	147.5	47.5	**200**
7	Potassium	Flame photometry	40.8	3.7	4.2	**----**
8	Fluoride	SPANDS method	0.58	0.112	0.121	**0.6-1.5**
9	Iron	Thiocynate method	0.86	Nil	Nil	**0.3**
10	Chromium	Diphenylcarbazide method	0.005	Nil	Nil	**0.05**
11	Manganese	Persulphate method	**Nil**	**Nil**	**Nil**	0.1

Table: 03

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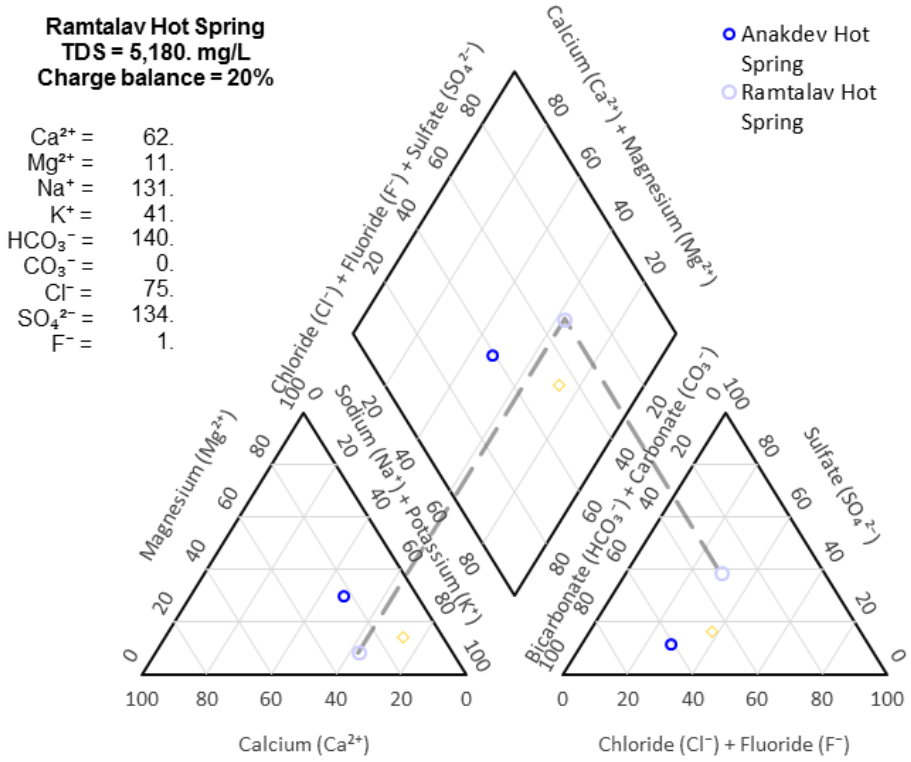

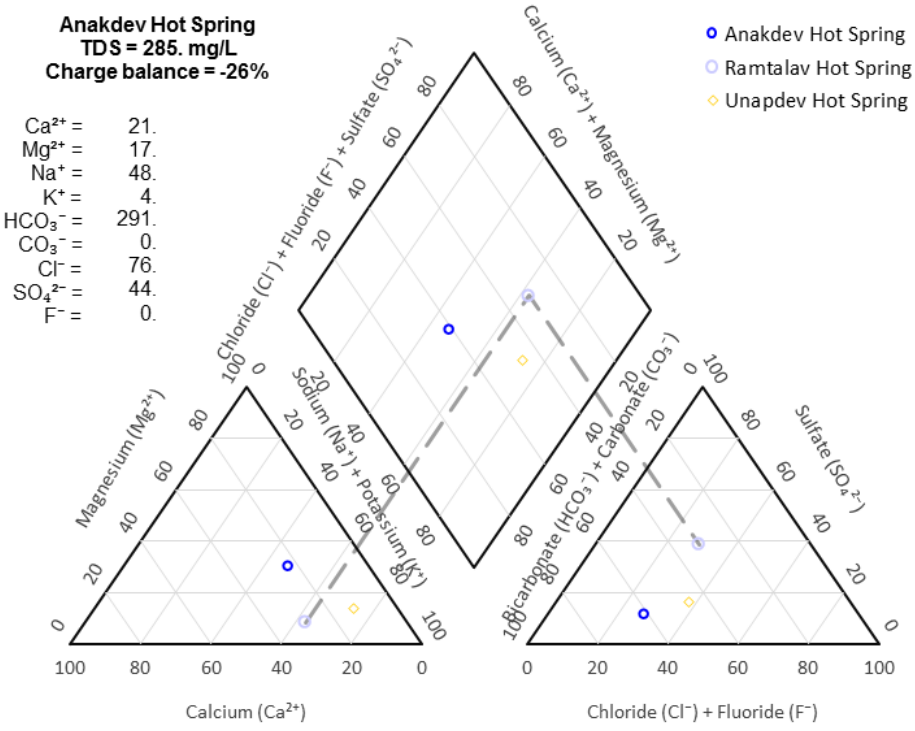

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Parameter	WHO (mg/L)	USA (mg/L)	EU (mg/L)	New Zealand (mg/L)	Australia (mg/L)	Japan (mg/L)	India (mg/L)	RHS1 (mg/L)	UHS1(mg/L)	AHS1 (mg/L)
Chloride	**250**	250	250	**250**	250	250	**250**	74.5	72	76
Phosphae	**---**	0.025	0.1	**0.05**	0.1	0.1	**0.1**	0.102	0.21	0.28
Sulphate	**500**	N.S	250	N.S	N.S	N.S	**400**	134.44	42	44
Calcium	**75**	N.S	200	N.S	N.S	N.S	**75**	62.12	22.05	21.20
Magnesium	**30**	N.S	50	N.S	N.S	N.S	**30**	11.2	15.2	17.2
Sodium	**200**	N.S	200	N.S	N.S	N.S	**200**	130.6	147.5	47.5
Potassium	**----**	N.S	12	N.S	N.S	N.S	**N.S**	40.8	3.7	4.2
Fluoride	**0.6-1.5**	4	1.5	**1.5**	1.5	1.5	**1.5**	0.58	0.112	0.121
Iron	0.86	0.3	0.2	**0.2**	0.3	0.3	**0.3**	0.86	Nil	Nil
Chromium	0.005	0.1	0.5	**0.05**	0.05	0.05	**0.05**	0.005	Nil	Nil
Manganese	Nil	0.05	0.5	0.08	0.1	0.05	**0.1**	Nil	Nil	Nil
***N.S-Not specified , **RHS1-Ramtalav hot spring,UHS1-Unapdev Hot Spring,AHS1-Anakdev Hot Spring**										

Based on ionic parameters, with compare world health permissible limits, study reveals that, Chloride: The chloride levels in Ramtalav, Unapdev, and Anakdev hot springs are 74.5 mg/L, 72 mg/L, and 76 mg/L, respectively. These values are below the WHO permissible limit of 250 mg/L, indicating good water quality. The slight variation in chloride concentrations may be due to differences in the geological composition of the hot spring sources.[9][10] Phosphate concentrations in Ramtalav, Unapdev, and Anakdev hot springs are 0.102 mg/L, 0.21 mg/L, and 0.28 mg/L, respectively. Since there is no WHO limit provided, it's difficult to assess the significance of these values. However, phosphate levels are generally low, suggesting minimal contamination from agricultural runoff or wastewater.[11]Sulphate levels vary significantly among the hot springs, with concentrations of 134.44 mg/L in Ramtalav, 42 mg/L in Unapdev, and 44 mg/L in Anakdev. While all values are below the WHO limit of 500 mg/L, the higher sulphate concentration in Ramtalav may indicate the presence of sulphur-rich geological formations. Calcium and Magnesium: Both calcium and magnesium concentrations are highest in Ramtalav hot spring (62.12 mg/L and 11.2 mg/L, respectively), followed by Unapdev and Anakdev. These minerals contribute to water hardness and are essential for various biological processes.[12]The EDTA method ensures accurate measurement of calcium and magnesium levels. Sodium and Potassium: Sodium levels are relatively high in Unapdev hot spring (147.5 mg/L) compared to Ramtalav and Anakdev. Potassium concentrations are generally low in all hot springs. The flame photometry method provides reliable measurements of these ions, which play important roles in fluid balance and nerve function. Fluoride concentrations are within the recommended range of 0.6-1.5 mg/L in all hot springs, indicating optimal levels for dental health. The SPANDS method ensures accurate detection of fluoride ions. Iron, Chromium, and Manganese: Iron levels are detectable only in Ramtalav hot spring (0.86 mg/L), while chromium and manganese are not detected in any of the samples. These trace metals are often present in natural waters but may not be present in significant concentrations in these hot springs.[13]

The comparative analysis of metallic and non-metallic compounds in hot spring waters is significant in physico-chemical research of hot spring water.[14][15] On the above heads, Ramtalav, Unapdev, and Anakdev against international standards highlights distinct variations across various parameters. Ramtalav and Anakdev generally exhibit concentrations slightly below or within permissible limits set by the WHO, USA, EU, and Australia for chloride, while Unapdev closely aligns with WHO and USA guidelines. Elevated levels of phosphate, sulphate, calcium, magnesium, sodium, and potassium in Ramtalav and Unapdev indicate potential therapeutic benefits, although Anakdev's calcium levels fall slightly below WHO standards. Additionally, Ramtalav's higher levels of iron, chromium, and manganese may offer unique therapeutic advantages. Conversely, the absences of these trace metals in Unapdev and Anakdev ensures safety for balneotherapy, underscoring their suitability for therapeutic use and potential in holistic healing practices. [16]

Average Heavy-metals concentration analysis of hot springs water:

Heavy-metals	Average Concentration (mg/L) ±
Iron (Fe)	0.2867 mg/L
Chromium (Cr)	0.00167 mg/L

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Manganese (Mn)	14.5333 mg/L
Chromium	0.00167 mg/L

Table: 04

The levels of common heavy metals were also determined in Khandesh province hot springs, iron (Fe), chromium (Cr),manganese (Mn), Very low concentrations of the heavy metals were detected: iron (0.2861), chromium (0.00167),manganese (14.53), Table 2 shows the heavy metals concentration in hot springs of Khandesh province .

Therapeutic as well as biological importance assigned by same previous studies on hot springs.[21] Heavy metals are natural elements of natural waters and some of them like iron, manganese are biologically important in the aquatic environment when present at low concentrations.[17] [13]Heavy metals may enter waters from various sources, for instance, the weathering of rocks and soil. Human activity due to farming, mining, secondary and tertiary activities are the source of heavy metals is the waters. [18][19]Novel studies have revealed that heavy metals in low concentrations are important for many metabolic and cellular activities of bacteria but at higher concentrations, they become cytotoxic to the bacteria and affecting the growth, morphology, metabolic properties and activities [20]

The analysis of average common heavy metals in the hot springs of Khandesh province revealed that; very low concentrations of iron, chromium, and manganese. With iron at 0.2861 mg/L, chromium at 0.00167 mg/L, and manganese at 14.53 mg/L, these findings suggest that the hot springs are suitable for balneotherapy, offering therapeutic benefits without significant heavy metal contamination.[22][23] Balneotherapy utilizing these hot springs may promote relaxation, improve circulation, and alleviate musculoskeletal ailments, providing holistic healing experiences for individuals seeking natural remedies.

II. Conclusions

Hot springs of Ramtalv, Unapdev and Anakdev in Khandesh province of northern Maharashtra state in India, attributed to the unique physico-chemical composition for therapeutic uses for balneotherapy centres. International guidelines and standards of WHO,USA,EU,Newzeland ,Australia ,Japan and India on permissible limits of physic-chemical components in water as nearby threshold limits, On the basis of the high levels of certain inorganic compounds likeCl,PO4 ,SO4, Ca, Mg, Na, K. F, heavy metallic Compounds:Fe,Cr,Mn also determination is unique. Therefor present, study revels, higher potentiality in Khandesh province can be future hub for balneotherapy as well in health tourism province in India.

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